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9 July 2009

Mr. Tim Gray, Esquire
Forman, Perry, Watkins, and Krutz & Tardy LLP
200 South Lamar Street
City Centre Building, Suite 100
Jackson, MS 39201-4099

Re: Summary Report
Lewis E. Knapper and Linda Knapper vs. Radiator Specialty et al.
EPI Project # 29213

Dear Mr. Gray:

This report summarizes my opinions regarding issues specifically related to the alleged exposure of Mr. Lewis E. Knapper to benzene as a result of his use of Liquid Wrench products and Safety-Kleen parts washer solvents that were alleged to contain benzene as a component of the product. In the original complaint Mr. Knapper claimed exposures to Liquid Wrench from 1962 to 1979. Liquid Wrench contained a benzene-containing raffinate as one of its constituents from 1960 through 1978.[1,2] It is alleged by Mr. Knapper that his use of Liquid Wrench and Safety-Kleen parts washer solvent is associated with his Acute Myelogenous Leukemia (AML), which was diagnosed on 8 March 2008. Mr. Knapper smoked one half pack of cigarettes per day from 1964 to 1976 according to his deposition testimony.

I have been an industrial hygienist for more than 32 years. Currently, I am President of Environmental Profiles, Inc. (EPI) in Baltimore, Maryland. Formerly, I was with the National Institute for Occupational Safety and Health and led a group of industrial hygienists conducting research for the National Occupational Exposure Survey. As an industrial hygienist for the United States Coast Guard, I conducted thousands of exposure assessments of a wide range of products, including numerous benzene-containing materials. My responsibilities also included the management of the occupational medical monitoring program for the 5th Coast Guard District. I was President of the Chesapeake Section of the American Industrial Hygiene Association (AIHA) and was a member of the national AIHA Product Health and Safety Committee and the Emergency Response Planning Committee. I have also authored the *Health and Safety Audits Manual*, published by Government Institutes, and the *AIHA Hazard Communication Guide*, published by the AIHA. The American Board of Industrial Hygiene certifies me as an industrial hygienist and the Board of Certified Safety Professionals certifies me as a safety professional. My curriculum vitae is appended to this report (Appendix I). Environmental Profiles, Inc. charges $285 per hour plus expenses for my time in preparation and testimony in this matter.

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1 Complaint

2 Product Date First Sold [RSC 00186 - RSC 00187]

PENGAD-Bayonne, N. J.
EXHIBIT
1

Executive Summary:

- Applying the plaintiff's industrial hygiene expert's methodology for determining inhalation exposure resulted in a cumulative inhalation benzene exposure of 0.8 ppm-yrs for Mr. Knapper. This cumulative exposure dose was well below the current and former benzene health standards.
- The plaintiff's industrial hygiene expert's methodology for determining dermal dose has not been scientifically validated, is not reliable, nor is it a standard and acceptable industrial hygiene practice for quantifying dermal dose for comparison with the occupational health standard.
- When developing the occupational health standards and guidelines, OSHA and other standard and guideline setting agencies accounted for the dermal route of exposure and used the inhalation route of exposure as the surrogate for both dermal and inhalation exposures.
- The Liquid Wrench product labels met the requirements of the Federal Hazardous Substance Act (FHSA) regulations during the period of time from 1960 to 1978 and conveyed the information necessary for Mr. Knapper to properly manage the hazards of the product.

Exposure Assessment Methodology

As a certified industrial hygienist, I rely upon the following basic tools in order to conduct an exposure assessment of personal occupational exposures such as Mr. Knapper's:

1. a characterization of the workplace;
2. a characterization of the job and tasks (including frequency and duration of exposures);
3. a characterization of the products (e.g., volatility, relative toxicity, etc.);
4. a characterization of the relevant safety and health regulations and the associated exposure limits;
5. an appropriate association of tasks, environment, job descriptions and chemical agents with the individual exposures being evaluated;
6. classification of workers into Similar Exposure Groups (SEG's) based on an appropriate association of tasks, environment, job descriptions and chemical agents with the individual exposures being evaluated;
7. use of the accepted air sampling and analytical techniques for occupational exposure to benzene; and,
8. a comparison of the dose with occupational exposure limits to evaluate relative risk.

This process is further defined in the standard industrial hygiene text, *A Strategy for Assessing and Managing Occupational Exposures* and *The Occupational Environment: Its Evaluation and Control.*[3]

3 Mulhausen, John R. and Joseph Damiano. A Strategy for Assessing and Managing Occupational Exposures, 2nd Ed. American Industrial Hygiene Association, Fairfax, VA 1998 and DiNardi, SR. The Occupational Environment – Its Evaluation and Control. AIHA Press, Fairfax, VA 1997.

Retrospective Exposure Assessment

The purpose of a retrospective exposure assessment is to determine the exposure scenarios where a worker or group of similar workers were exposed to specific stressors (chemical, physical agents, or biological agents) of concern, the time period of each exposure scenario, and the frequency, duration, and intensity of each exposure. These assessments can encounter many obstacles, such as, a lack of access to the worker, changes to the work environment over time, lack of historical process information, lack of credible sampling data, and complex or incomplete work histories. Modeling techniques may be used to characterize exposure dose when the appropriate information is available.[4]

Retrospective (Historic) Exposure Assessment is Part of the Field of Industrial Hygiene

- Retrospective exposure assessment and individual dose reconstruction are tools that have been used by industrial hygienists, epidemiologists, and other health professionals for many years, and are a part of the traditional exposure assessment process.[5,6,7,8]
- Exposure assessments and retrospective exposure assessments are methods upon which industrial hygienists and other trained experts routinely rely. Industrial hygienists contribute to the development of the information necessary to reconstruct historical exposure dose.

Exposure Assessment Models are used in Standard Industrial Hygiene Practice

- Airborne Exposure Assessment for solvent mixtures using the Near field/Far field model has been tested and the results of various studies have recently been published to better determine the reliability of this method.[9,10,11]

Retrospective Exposure Assessments can be useful tools to evaluate historic exposures

Retrospective exposure assessments are useful tools to calculate historic exposures only when the methods employed are standardized and validated, and factors used in the estimates are truly representative of the historic products, work practices, and environmental conditions. OSHA and NIOSH have published standard methods to measure many different solvents in the air. Sampling and analytical error rates have been measured and are reported for each of these methods.[12]

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4 Viet SM, Stenzel MR, Rennix CP, and Arnstrong TW. AIHA Guideline 11 – 2008 Guideline on Occupational Exposure Reconstruction. American Industrial Hygiene Association, Fairfax, Virginia. 2008.

5 Esmen N.A. "Retrospective Industrial Hygiene Surveys" Am. Ind. Hyg. Assoc. J. 40 (1979): 58-65.

6 Checkaway et al., Industrial Hygiene Involvement in Occupational Epidemiology, Am. Ind. Hyg. Assoc. J. 48 (1987) 515-523.

7 Baumgarten M, J. Siemiatycki, G. Gibbs, Validity of Work Histories Obtained by Interview for Epidemiologic Purposes, Am. J. Epidem. 118 (4) 1983.

8 Hemon, et al. Retrospective Evaluation of Occupational Exposures in Cancer Epidemiology: A European Concerted Action of Research, Appl. Occup. Environ. Hyg. 6 (6) 1991.

9 Nicas M, Plisko MJ, and Spencer JW. "Estimating Benzene Exposure at a Solvent Parts Washer." Journal of Occupational and Environmental Health 3(2006): 284-91.

10 Spencer, John W. and Plisko, Marc J. 'A Comparison Study Using a Mathematical Model and Actual Exposure Monitoring for Estimating Solvent Exposures During the Disassembly of Metal Parts', Journal of Occupational and Environmental Hygiene, 4 (2007): 253 – 259.

11 Plisko M and Spencer JW. "Evaluation of a mathematical model for estimating solvent exposures in the workplace." JCHAS (2008):

12 NIOSH Manual of Analytic Methods is available at http://www.cdc.gov/niosh/nmam/ and includes validated sampling and analytical methods. OSHA validated sampling and analytical methods are available at http://www.osha.gov/dts/sltc/methods/index.html. Information regarding limit of detection, range, and precision; i.e. sampling and analytical error is provided for validated NIOSH and OSHA methods.

Standard methods for air sampling and analysis are published, readily available, and widely used.[13] By contrast to air monitoring, the assessment of dermal exposures and dermal dose are not relevant, reliable, or consistent with standard industrial hygiene practice and can not be used to retrospectively evaluate dermal exposures.

> "In comparison to air sampling and even biological monitoring, dermal dosimetry is not a simple or routine procedure. Thus far, its use is limited to research and to specially designed studies. An individual applying dermal dosimeters should be thoroughly trained regarding the placement and retrieval of the dosimeters and recording of observations and other information about the activity. In addition to objective parameters, observed work practices can also have statistically significant important influences on dermal exposure, as observed by Popendorf."[14]

Dermal Exposure Assessment is not a standard Industrial Hygiene method for quantifying exposures for comparison with Occupational Exposure Limits.

- The tools to quantify dermal exposure to organic solvents such as benzene have not been standardized nor validated and remain in development.[15, 16] Quantitative dermal exposure assessment is not standard practice for industrial hygienists.
- The dermal estimate relied upon by the plaintiff's exposure assessment expert is based on the penetration rate for a solvent through a person's skin (flux). Flux values for benzene (100% or neat) have no known error rate. The issue is further complicated, because the flux value for a solvent in a product mixture is highly dependent on what other materials are in the mixture, at what relative percentages, and numerous environmental factors (air speed across the surface, temperature, etc).
- The Occupational Safety and Health Administration (OSHA) considered dermal routes of exposure in the development of the Benzene standard. After addressing dermal exposures in the development of occupational exposure limits for benzene, OSHA set an airborne exposure limit. Rather than add the results of dermal exposure models to measured airborne exposures (acquired through validated, standardized methods), OSHA relied upon airborne concentrations derived from epidemiological studies in order to evaluate workplace exposures to benzene and benzene-containing solvents.
- There is no dermal exposure limit. A separate dose calculation was not added to the inhalation dose when developing the occupational health standards; i.e., OSHA Permissible Exposure Limit (PEL), American Conference of Governmental Industrial Hygienists Threshold Limit Values (ACGIH TLV®) and the National Institute for Occupational Safety and Health Recommended Exposure Limits (NIOSH REL).
- OSHA, ACGIH, and NIOSH neither require nor recommend quantifying dermal exposures in specific health standards.

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13 ibid.

14 OSHA. "Dermal Dosimetry" http://www.osha.gov/SLTC/dermalexposure/dosimetry.html

15 Fiserova-Bergerova V. "Letter to the Editor: RE: Response to Bunge's Letter to the Editor." American Journal of Industrial Medicine 34 (1998): 91.

16 Jakasa I and Kezic S. "Evaluation of in-vivo animal and in-vitro models for prediction of dermal absorption in man." Human & Experimental Toxicology 27 (2008): 281-288.

Dermal Flux Models have not been Validated for Solvent Mixtures and are Therefore Unreliable

Uncertainties in dermal exposure models included the selection of input values for flux (the rate of movement of a fluid through the skin), and other individual specific values such as surface area exposed, exposure duration and exposure frequency. For example, flux can be impacted by the percentage of benzene in the mixture (raffinate-containing formulations of Liquid Wrench were mixtures of multiple chemicals); and the percentage and type of co-solvents (cyclohexane, aromatics, alcohols, or water) [i.e. raffinate-containing Liquid Wrench formulations included toluene, xylenes, ethylbenzene, cyclohexane, methyl cyclohexane and other solvents].

One of the major sources of variability in a dermal exposure model is the percentage of a chemical in a mixture and the other characteristics of the other chemicals in the mixture. The flux values for pure (neat) benzene from four studies varied from 0.1 to 1.85 mg/cm^2-hour (an 18 fold variation)[17,18,19,20]. This shows the variability in experimentally derived flux values for pure benzene. For benzene in solvent mixtures such as gasoline the measured flux values ranged from 0.00271 to 0.0626 mg/cm^2-hour for gasoline containing 0.39% to 5% benzene, a 23-fold difference[21,22]. Additional studies demonstrated the significant variability in determining the flux value for benzene in hydrocarbon mixtures.[23,24] See Appendix II. Many of the dermal exposure studies have "employed compounds applied to the skin in aqueous or single solvent systems, a dosing scenario that does not mimic occupational, environmental or pharmaceutical exposure where compounds are often exposed with associated solvents, contaminants or specific formulation additives. It is well known that such factors modulate absorption of compounds".[25]

Fiserova-Bergerova (1993) explained that when inhalation is not the primary route of exposure for solvents, the lungs will aid in the excretion of the absorbed solvent. This represents another factor that has not yet been addressed in dermal flux models and is among the reasons why biological monitoring, (collection of blood and/or urine samples), is more representative of total absorbed dose estimates of the amount absorbed into the body.

> "Dermal absorption is affected by other routes of entry of the chemical into the body. The role of the lungs in the exposure to volatile chemicals deserves special attention. Dermal

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17 Blank, I.H., and D. J. McAuliffe. "Penetration of Benzene through Human Skin." J. Invest. Dermatol, 85 (1985): 522-526.

18 Franz, TJ. Chapter 5 "Percutaneous Absorption of Benzene." In Advances in Modern Environmental Toxicology. Volume VI – Applied Toxicology of Petroleum Hydrocarbons. Editors: MacFarland, Holdsworth, MacGregor, Call, and Lane. Princeton Scientific Publications, Inc. 1984: 61-70.

19 Hanke, J., T. Dutkiewicz, and J. Piotrowski. 1961. "The Absorption of Benzene through the Skin in Man." Med. Pracy, 12 (1961): 413-426. (OSHA translation and reprint with permission in International Journal of Occupational and Environmental Health, 6 (2000): 104-111.)

20 Loden, M. "The in vitro Permeability of Human Skin to Benzene, Ethylene Glycol, Formaldehyde, and n-Hexane." Acta Pharmacol. et Toxicol., 58 (1986): 382-389..

21 Adami, et al. "Penetration of benzene, toluene and xylenes contained in gasolines through human abdominal skin in vitro." Toxicology in Vitro 20-8 (2006): 1321-1230.

22 Blank, I.H., and D. J. McAuliffe 1985

23 Blank, I.H., and D. J. McAuliffe 1985

24 Bowman A and Maibach HI. "Influence of evaporation and solvent mixtures on the absorption of toluene and n-butanol in human skin in vitro." Annals of Occupational Hygiene 44-2 (2000): 125-135.

25 Riviere, JE and Brooks, JD. "Prediction of dermal absorption from complex chemical mixtures: incorporation of vehicle effects and interactions into a QSPR framework." SAR and QSAR in Environmental Research, 18 (2007):1, 31 — 44.

absorption increases the concentration in venous blood. Consequently, pulmonary uptake is reduced or is replaced by elimination." If the concentration of the mixed venous blood is greater than the concentration of the arterial blood, the pulmonary wash out occurs. "Extensive pulmonary clearance of volatile chemicals reduces their potential for dermal toxicity." They pulmonary wash-out was documented experimentally for methanol and xylene.[26]

The rate of absorption can be dramatically impacted by the volatility of the various components of the mixture. Franz stated, "further work is needed …to define the role of vehicle (solvents or mixtures other than pure benzene) in controlling percutaneous absorption of benzene."[27] Bowman and Maibach (2000) commented, "Industrial exposure is also often to mixtures and seldom to the neat compound or solvent. If one or several compounds are volatile, evaporative loss of one or several of these can dramatically change the absorption of the others as their relative concentrations are increased. Many organic solvents have a high vapour pressure and can be expected to have a substantial loss through evaporation when non- occluded skin is exposed."[28] For all the reasons noted in this section, benzene occupational health standards and guidelines are not based on dermal dose calculations.

Dermal modeling applied for purposes of calculating exposure dose is not a standardized or accepted industrial hygiene method for evaluating an individual's exposures to volatile mixtures such as Liquid Wrench, Safety-Kleen, or benzene for comparison with established occupational health standards. The degree of uncertainty associated with these models varies widely depending on the input values used to estimate the flux, (the rate at which a substance is absorbed through skin.[29]

Specific Reasons for the Lack of Reliability of Dermal Modeling are:

(1) The process for modeling dermal exposures has not been validated and there is no reproducible measure of its precision or accuracy. Dermal dose model calculations have no known error rate for pure constituents or solvent mixtures;
(2) Flux estimates for benzene have no known error rate, no known reliability, and no known reproducibility;
(3) Dermal flux models are particularly unreliable when evaluating solvent mixtures because the skin barriers do not behave in the same way to a neat (100%) benzene product, as they do to mixtures; and
(4) Methods to quantify exposures via the dermal route of exposure rely on direct measurement of the chemical of concern or other internal markers of exposure measured in blood or urine utilizing validated methods.

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26 Fiserova-Bergerova V. "Relevance of occupational skin exposure." Annals of Occupational Hygiene 37 (1993): 673-685. p. 677

27 Franz, p. 70.

28 Bowman A and Maibach HI. "Influence of evaporation and solvent mixtures on the absorption of toluene and n-butanol in human skin in vitro." Annals of Occupational Hygiene 44-2 (2000): 125-135.

29 OSHA Preamble to the Benzene Standard. Federal Register 52(176): September 11, 1987; pp. 34487-34505.

Mr. Lewis Knapper's Work History and Alleged Exposure to Liquid Wrench and Safety-Kleen Solvent

Mr. Knapper started working for his father part-time in New York as a plumber's helper in 1964 when he was 14 years old. He claimed to work three to four times per month with his father during the school year and three days per week in the summer. Mr. Knapper described his father as using Liquid Wrench to loosen up bolts and nuts that were rusted. Likewise, regarding his use of Liquid Wrench Mr. Knapper stated, for "anything that was rusted, I would use Liquid Wrench on."

In the second half of 1966, Mr. Knapper's family moved to Florida. After completing the eleventh grade in 1968, Mr. Knapper dropped out of high school and became a full time plumber's helper or apprentice plumber. Mr. Knapper worked five years as a plumber's helper (apprentice) to get his journeyman's plumber license and obtained his master plumber's license in 1999.

Mr. Knapper claimed to have used Liquid Wrench both professionally as a plumber and in his personal endeavors which included repairing lawn mowers, automobiles, and motorcycles.

Mr. Knapper claimed to have used Safety-Kleen parts washing tanks to clean parts starting in 1964 when he was 14 years old at four locations; Colintonio's home, a friend of Mr. Knapper's; in high school during automotive classes; while employed as a mechanic at the Citgo Service Station; and, at Jackson's Garage. The last time he used a Safety-Kleen parts washer was in 1967 at Jackson's Garage.

Mr. Knapper lived in New York from 1950 to1966 and from 1974 to 1976, in Texas 1976 to 1985, and in Florida from 1966 to 1974 and again from 1985 to the present.

Table I includes a summary of Mr. Knapper's job titles and potential exposure to benzene-containing products.

Table I: Lewis Knapper's Alleged Exposure History to Liquid Wrench and Safety-Kleen Solvents[30,31]

Approximate Date	Job Location	Job Title	Benzene Containing Products	Alleged Product Use: Frequency & Duration
1962	New York	Personal time	Liquid Wrench	Used fathers LW on go-carts, bicycles, lawnmowers.
1964-1966	New York, Plumber's Helper worked with father	Plumber's Helper	Liquid Wrench	School – 6 hours/month applied LW 2-3 min./month. Summer – 12 hours/month applied LW 10 min./month
1964-1966	Friend's House named Ronnie (Colintonio) cleaned lawn mower parts, brake parts, and car parts in SK parts washer.	Personal time	Safety-Kleen solvent	Used the parts washer once per week for an hour.

[30] Deposition Testimony of Mr. Knapper taken 13-14 January 2009
[31] Mr. Petty's Outline of Opinions Report, Appendix B, Mr. Lewis E. Knapper Telephone Log Sheet

Approximate Date	Job Location	Job Title	Benzene Containing Products	Alleged Product Use: Frequency & Duration
1964-1968	New York/Florida - repaired 50 motorcycles	Personal time	Liquid Wrench	1/8 can per motorcycle
1964-1968	New York/Florida - repaired 100 lawnmowers		Liquid Wrench	¼ can per lawnmower
1964-1968	New York/Florida – repaired/rebuilt 6 cars		Liquid Wrench	Used 2.5 cans personally on one "54 Lincoln – one can per week, ½ can on the other 5 cars.
1966	New York - Citgo Gas Station	Pump attendant, mechanic	Liquid Wrench, Safety-Kleen solvent	Used a can per week of LW. Used parts washer for 1.5 hours every day.
1966	New York – High school automotive glass class	Student	Safety-Kleen solvent	Used parts washer 30 min./week
1966	Florida - Jackson's Garage	Mechanic	Liquid Wrench, Safety-Kleen solvent	One can per week LW. Used parts washer 10 hrs./week
1968-1975	Florida/New York - Plumber's Helper	Plumber's Helper	Liquid Wrench	Two cans LW per house repiping, 4 squirts LW per Kitchen sink, ¼ oz. per lavatory, 1/8 oz. per tub/shower.
1976 , 6 months	No work, had surgery		None	none
1976, 6 months	New York – Building Engineer part time for 2 months, back to full time 4	Building Engineer/Plumber	Liquid Wrench	Used LW for 15 min. per galvanized joint.
1977-1984	Texas – Plumber various employers and independent	Plumber	Liquid Wrench	Used one can LW per week up to early 1980s.
1985+	Florida – Plumber various employers and independent	Plumber	None	None

Ronald Coleman Co-worker Testimony

Mr. Ronald Coleman was a plumber and first met Mr. Knapper in April of 1979 when he moved from New York to Houston, Texas. They were both working at the same job installing copper and sanitary piping, and final fixtures, e.g. toilets, sinks, water heaters, lavatories, tub/showers, washing machine, etc. This work was all new construction. Mr. Coleman recalled seeing Mr. Knapper use Liquid Wrench on a 1955 Chevy, and on his van, and motorcycle. The only other time Mr. Coleman recalled seeing Mr. Knapper use Liquid Wrench was on a renovation job, where he was using the Liquid Wrench to break loose nuts on faucets, sinks and toilets.

Mr. Coleman testified that when he used Liquid Wrench, he would wait from 30 seconds to five minutes before attempting to remove the rusted or frozen fitting. He indicated that the longer you wait, the more effective the Liquid Wrench would be. Mr. Coleman stated that when he would apply Liquid Wrench to a toilet bowl, he would do another task to allow the Liquid Wrench to do its job and thereby make the best use of his time. This method of using Liquid Wrench is consistent with the design of the product, which is to apply the Liquid Wrench and wait for a period of time before attempting to remove the fitting.
Mr. Coleman stated that he brought four or five cans of Liquid Wrench with him when he first moved to Texas in December of 1978. He did not purchase any Liquid Wrench in Texas and stated that the four or five cans lasted him into the mid-1980s. Therefore, these five cans of Liquid Wrench lasted Mr. Coleman for approximately six years. Mr. Coleman's usage of

Liquid Wrench would have been estimated at less than one can per year as compared to Mr. Knapper's use of Liquid Wrench of one can per week as a plumber.

Description of the Raffinate-Containing Liquid Wrench Product

Liquid Wrench was a penetrant designed to aid in the loosening of metal on metal joints that are difficult to get apart. Testimony by Mr. Knapper indicated that Liquid Wrench was applied to bolts and fittings that were difficult to remove, and then allowed to soak in for a period of time (few minutes to 15 minutes)[32] before attempting to remove the bolt or fitting.

The Liquid Wrench product had several different formulations, which were typically sold in four (4), eight (8), and 16-ounce drip cans depending on the time period. After approximately 1971, the four (4) ounce cans were available only in the non-raffinate formula. Raffinate is a coal derivative that contains varying solvent constituents. Table II lists the components of the raffinate-containing and non-raffinate containing Liquid Wrench products.[33] The raffinate-containing Liquid Wrench product was manufactured for approximately 18 years between 1960 and 1978.[34] Non-raffinated Liquid Wrench (referred to as "deodorized") was also available during this same time period. Liquid Wrench products that did not include raffinate also did not include benzene.[35] Both Liquid Wrench formulations contained oil which resulted in an "oily" feel to the product.

Table II: Components of Liquid Wrench (formulations with and without raffinate)[36, 37]

Components	% Content in Raffinated Liquid Wrench	% Content in Deodorized Liquid Wrench
Kerosene	--	89.2
Ba Sulfonate	--	0.45
Na Sulfonate	--	0.36
Mineral Seal Oil	--	8.8
Odorant	1.15	1.07
Graphite Disp.	0.32	0.12
Naphthenic oil	12.22	--
Raffinate (components as % in the final product)		--
Benzene	4.39	
Toluene	5.25	
o-Xylene	1.76	
m-Xylene	6.15	
p-Xylene	2.6	
Ethyl Benzene	4.39	
Cyclohexane	19.3	
Methylcyclohexane	10.5	
Aliphatic & Aromatic HC	Approx. 32	

32 Deposition of Lewis Knapper taken 13 January 2009, pgs 23-26

33 Safety Data Sheet for Raffinate, USS Chemicals, 1967.

34 Table P-4 Typical Analysis of Clairton Raffinate [USS 09 – USS 10], and Appendix No. 2 to LR-09A "Liquid Wrench No.1 [RSC 00025]

35 Product label exhibit 17 Wells deposition

36 Table I (Attachment to LR-09-A) Properties of raffinate (D-3) [Bate #RSC00023]

37 Appendix No. 2 to LR-09A: Liquid Wrench No. 1, Formulas in %/Weight [Bate # RSC00160]

Raffinate-Containing Liquid Wrench Product Label

The Federal Hazardous Substances Labeling Act of 1960, modified in 1966 changed the name of the Act to Federal Hazardous Substances Act (FHSA) and included provisions of child precautionary labeling. Also, in 1964, Congress delegated the regulation of benzene-containing consumer products to the FHSA. See Table III for the regulations as they pertain to the Liquid Wrench products.

According to testimony[38] by James Wells, who worked with Radiator Specialty Company, Liquid Wrench container labels included all necessary information and met the requirements of the FHSA from the time he joined the company in 1972 forward and historically as well. Based upon his review of available product labels for the raffinate-containing Liquid Wrench product, the labels contained the necessary warnings recommended by labeling guidelines and regulatory authorities for each time period.[39] Labels indicated the presence of 'benzol" (i.e. benzene), the appropriate signal words i.e. danger, and skull and crossbones symbol.

Consumer Product Safety Regulations

TABLE III: Label for Liquid Wrench (Raffinate-containing) Compared to Federal Labeling Regulations

Hazardous Substances Act[39]	Label Contents[40]	Comments
Applies to consumer products that are "intended or packaged in a form suitable for use in the household." Cautionary labeling for substances defined as hazardous under FHSLA include the following:	Labeling was on the front and back of the Liquid Wrench can.	Liquid Wrench was sold in hardware, auto parts and department stores.
Name and place of business of the manufacturer, packer, distributor or seller	Radiator Specialty Company Charlotte, NC 28201	Meets U.S. product labeling requirements 1960 to 1972.
Common or Usual name or the chemical name of the hazardous substance…	Liquid WRENCH	Common name.
The signal word "DANGER" on substances which are extremely flammable, corrosive or highly toxic. The word 'poison' for any hazardous substance which is defined as 'highly toxic.'	**SIGNAL WORD:** **"DANGER – POISON"* ***	In 1962, the consulting company, Foster Snell, determined that based on the results of their testing, that raffinate-containing LW met the definition of "Hazardous" under the law.

38 Deposition of James Wells, taken 7 December 2006

39 Based on the 1960 Federal Hazardous Substances Labeling Act of 1960 as modified in 1966. Major changes included a change in the name of the Act to Federal Hazardous Substances Act and provisions of child precautionary labeling. Also, in 1964, Congress delegated the regulation of benzene-containing consumer products to the FHSA in a February 1964 Federal Register Notice (pages 1802-1803) Currently, CPSC requires consumer products containing benzene at levels of five percent (5%) or more by weight to include the statement "… inhalation of the vapors of products containing 5% or more by weight of benzene may cause blood dyscrasias…" 16 CFR 1500.14(b)(3)(i).

40 "The label declarations must be located prominently, in the English language, in conspicuous and legible type." [FHSLA 1960]

Hazardous Substances Act[39]	Label Contents[40]	Comments
"Because inhalation of the vapors of products containing 5 percent or more benzene may cause blood dyscrasias, such products shall be labeled with the signal word "danger," the statement of hazard: Vapor harmful," and the word "poison," and the skull and crossbones symbol. [FR 6 February 1964 p 1802-3]	**SYMBOL:** "Skull and Crossbones"	Skull and crossbones symbol was appropriate for the raffinate-containing LW product, but not for other LW formulations.
Precautionary measures describing the action to be followed or avoided. The statement 'Keep out of the reach of children,' or its practical equivalent.	**PRECAUTIONARY MEASURES:** "CAUTION: Contains Benzol. Use only with adequate ventilation. Avoid prolonged or repeated breathing of vapor and contact with skin. Harmful of ingested. Keep out of reach of children"	1966 amendments to the Federal Hazardous Substances Act required provisions of child precautionary labeling.
Instructions for handling and storage of packages which require special care in handling or storage. An affirmative statement of the principal hazard, such as 'flammable' 'vapor harmful,' 'causes burns,' 'absorbed through skin,' or similar wording descriptive of the hazard.	**Flammability Warning:** **"CAUTION** – FLAMMABLE MIXTURE, DO NOT USE NEAR OPEN FIRE OR FLAME" "**FLAMMABLE** VAPOR HARMFUL HARMFUL or FATAL IF SWALLOWED"**	The signal word caution is applied to the level of flammability of the product. FHSA regulations would also call for the use of the CAUTION – NOTE: "Any article that presents more than one type of hazard (for example, if the article is both "toxic" and "flammable") must be labeled with an affirmative statement of each such hazard…" [21 CFR 191.107, 1964]
Instruction, when necessary or appropriate, for First Aid treatment.	"**FIRST AID:** Call Physician immediately if contacted with skin, wash thoroughly, for eyes flush gently 15 minutes. Acute vapor exposure, immediately move to fresh air – keep quiet. If breathing has stopped, begin artificial respiration. If swallowed, do not induce vomiting."**	Standard First Aid language was applied based on the definitions of health hazards in FHSA and the use of standard phrases at the time.

** In the special case of petroleum distillates, "…in addition to oral toxicity resulting in systemic poisoning, are hazardous because of aspiration into the lungs with resulting chemical pneumonitis, pneumonia, and pulmonary edema, the signal word "danger" is specified. The statement of hazard shall include "Harmful or fatal if swallowed" For Kerosene and related petroleum distillates, the label shall also bear the statement, "If swallowed, do not induce vomiting."

Liquid Wrench Worker Exposure Studies

EPI Study: An Evaluation of Benzene from the Application and Use of a Prepared Liquid Wrench Solvent in Static Environmental Conditions

The generation of airborne benzene vapor from a solvent is dependent on many factors including the vapor pressure of the solvent components, as well as environmental conditions such as temperature, relative humidity and ventilation. In order to quantify the likely exposures to benzene of workers using Liquid Wrench, EPI performed a study in August 2002 to evaluate the exposure of a worker and a helper to Liquid Wrench containing various weight concentrations of benzene (see Appendix III - *"Exposure Assessment: An Evaluation of Benzene from the Application and Use of a Prepared Liquid Wrench Solvent in Static*

Environmental Conditions.") In order to evaluate these exposures, three batches of Liquid Wrench were spiked with known weight percentages of benzene. Specifically, preparations of the Liquid Wrench/benzene (LW/benzene) solution were made in 1%, 7% and 30% concentrations by weight.

Three valve assemblies, each containing at least three flanges with rusted bolts and nuts were used during the study. For each of the three valve assemblies, Liquid Wrench containing 1%, 7% and 30% benzene was used to free the bolts and nuts on the flanges. Each weight percentage of benzene in Liquid Wrench was used for a period of two hours.

Personal and area air monitoring for benzene were completed on the worker and helper during each two-hour trial where each Liquid Wrench/benzene weight concentration was used. In addition to the two-hour sampling periods, 15-minute personal breathing zone samples were also obtained. The workplace ventilation was measured during the study and found the air movement to be between zero and six feet per minute (fpm), which was representative of static ventilation conditions.

Table IV provides a summary of the air sample results. Based upon the work environment where Mr. Knapper may have used Liquid Wrench, his likely exposure, if any, to benzene while using the Liquid Wrench would have been at or below the exposure concentrations reported above in the EPI study (static conditions).

Table IV: Summary of Worker Time Weighted Average (TWA) exposure levels measured in exposure reconstruction study using Liquid Wrench Product spiked with three different concentrations of benzene.

Sample Location	% Benzene in Liquid Wrench Solution	2-hr. TWA (ppm)	Range of 15-minute STEL averages (ppm)	Calculated 8-hr. TWA (ppm)
Worker	1		0.87 – 1.1	0.179
Helper	1		.024 – 0.27	0.035
Area	1	0.10 – 0.11		
Worker	7		1.15 – 4.87	0.351
Helper	7		0.24 – 0.92	0.060
Area	7	0.301 – 0.319		
Worker	30		1.88 – 3.51	0.585
Helper	30		0.23 – 2.1	0.160
Area	30	0.14		

EPI Study: Determination of Evaporation Rates for Benzene and a Benzene-Containing Solvent Mixture

EPI performed a study in June of 2009 to evaluate the rate at which benzene evaporates as a pure substance and from a reformulated product based on the historical production records of the raffinate-containing version of Liquid Wrench manufactured in the 1960 to 1978 timeframe. (see Appendix IV – *"Determination of Evaporation Rates for Benzene and a Benzene-Containing Solvent Mixture."*) The generation of airborne benzene vapor from a solvent is dependent on many factors including the vapor pressure of the solvent components as well as environmental conditions such as temperature, relative humidity and ventilation. EPI performed this study in order to determine the benzene content in a solvent mixture at a specific time after product dispensing and to determine the average concentration of benzene in the liquid mixture over a specified period of time once dispensed.

A total of 12 test trials were conducted over the three-day study period. Three (3) trials were conducted on each of the three days at chamber air speeds of approximately 27 feet per minute (fpm) and one (1) trial was conducted at a chamber air speed of approximately 50 feet per minute. Continuous sampling of solvent vapors was performed for the duration of each trial via the ChemSense 600 Mass Spectrometer unit. Additionally, 12 charcoal tube air samples (one per trial) and 18 Summa canister samples were collected and analyzed for benzene. Two (2) Summa canister samples were obtained per 27 fpm trial.

A ChemSense 600 Ion-trap mass spectrometer recorded the benzene mass concentration during each evaporation trial, which was subsequently converted to the cumulative mass of benzene evaporated per unit time. The half-life point of the evaporation period was also calculated. For Day 1 (evaporation of 20 ml of benzene from the surface of a glass plate) the average pure benzene evaporation time for Trials 1 through 3 was approximately 30 minutes with an average half-life point of less than eight (8) minutes. For Day 2 (evaporation of 20 ml of reformulated product containing 5.1% w/w benzene from a glass plate) the average benzene evaporation time for Trials 1 through 3 was approximately 12 minutes with an average half-life point of less than three (3) minutes. For Day 3 (evaporation of 20 ml of reformulated product containing 5.1% w/w benzene from simulated product use) the average evaporation time for Trials 1 through 3 was approximately 11 minutes with an average half-life point of less than three (3) minutes. Table V contains a summary of the Day 3 benzene half life data.

Table V: Time for Half of the initial Mass of Benzene to Evaporate

Trial Run	Half-life Time (min.)
Day 2, Trial 1 (20 ml LW on plate) ~ 27 fpm	3.05
Day 2, Trial 2 (20 ml LW on plate) ~ 27 fpm	2.76
Day 2, Trial 3 (20 ml LW on plate) ~ 27 fpm	2.67
Day 3, Trial 1 (20 ml LW on part) ~27 fpm	**2.79**
Day 3, Trial 2 (20 ml LW on part) ~27 fpm	**3.46**
Day 3, Trial 3 (20 ml LW on part) ~ 27 fpm	**1.76**
Mean	**2.67**
Day 2, Trial 4 (20 ml LW on plate) ~ 50 fpm	1.99
Day 3, Trial 4 (20 ml LW on gloves) ~ 27 fpm	1.94

Figure 1 depicts the cumulative mass of benzene from evaporation of 20 ml of reformulated product containing 5.1% w/w benzene from simulated product use. It should be noted that the Liquid Wrench was not dispensed onto the part until 1.78 minutes after the ChemSense 600 mass spectrometer started recording. Therefore, the time values depicted in the graph should have 1.78 minutes subtracted. Trials 1-4 were completed at an air speed rate of approximately 27 fpm. However, Trial 4 involved the application of 20 ml of Liquid Wrench on the gloves. The half-life of Trial 4 (1.94 minutes) fell in the range of 1.76 minutes to 3.46 minutes of the other three trials involving the evaporation of Liquid Wrench from the parts and gloves.

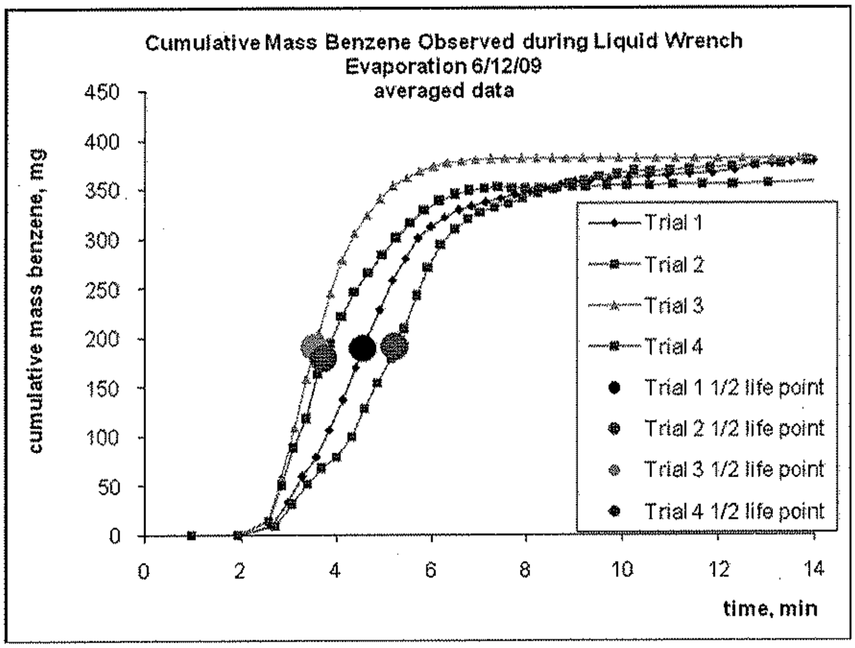

Figure 1: Depicts mass loss of benzene over time from application of Liquid Wrench on Parts for Trials one (1) through three (3). Trial four (4) Involved Liquid Wrench evaporating from application to gloves.

Description of the Safety-Kleen Parts Washer

Mr. Knapper described his first use of the Safety-Kleen parts washer when he was 14 years old at the Colintonio's house. He stated there were no labels or signs on the parts washer indicating it was a Safety-Kleen parts washer. Mr. Knapper believed it to be a Safety-Kleen parts washer because it looked like other Safety-Kleen parts washers he had seen at gas stations, only older. Mr. Knapper never saw anyone add solvent to this parts washer but stated he knew his friend's father would bring home cans of solvent from work and add that to the parts washer. Mr. Knapper used this parts washer one hour per week for approximately 6 weeks.

Mr. Knapper claimed to have used a Safety-Kleen parts washer while in high school. He stated the parts washer had a black and silver plate that said Safety-Kleen on it. This parts washer had an "SC" symbol on the back of the hood. Mr. Knapper claimed he had drained this parts washer from time to time but never refilled it. He used the parts washer for 30

minutes per week and claimed he would get solvent all over his hands, which subsequently ran down his arms. He would wash his hands at the end of shop class.

Mr. Knapper stated that he used a Safety-Kleen parts washer while employed at the Citgo Gas Station for about nine months in the 1965/66 timeframe. He claimed he used the parts washer two to three hours per week during school and five to six hours per week in the summer. He described the parts washer in the same manner as at his friend's house, the high school, and the one at Jackson's Garage. He claimed to use the parts washer two to three hours per week during the school year and five to six hours per week in the summer.

Mr. Knapper stated in his deposition testimony that he used a Safety-Kleen parts washer at Jackson's Garage for about one year in 1966. In the telephone conversation with Mr. Petty, he stated that he worked for Jackson's Garage for about 6 months in 1967. He claimed he used the parts washer two to three hours per week in in his deposition taken on 14 January 2009 and ten hours per week in his deposition taken on 13 January 2009. He believed this parts washer to be Safety-Kleen because it looked like all the other parts washers he had seen.

Plaintiff's Industrial Hygiene Expert's Report

Mr. Steven E. Petty has attempted to quantify Mr. Knapper's cumulative exposure to benzene over his working lifetime from the use of Liquid Wrench, Safety-Kleen solvents, and smoking of cigarettes. Mr. Petty did not quantify any benzene exposure due to other potential benzene-containing products that Mr. Knapper may have used throughout this time period.

Mr. Petty's approach to quantifying Mr. Knapper's historical exposure to benzene from Liquid Wrench was based on two routes of exposure: inhalation and dermal.

Mr. Petty's Inhalation Methodology

In order to calculate Mr. Knapper's inhalation exposure, Mr. Petty needed to estimate the concentration of benzene in the worker's air in parts per million (ppm) and determine the time of exposure in years resulting in a value of ppm-years. To determine the airborne concentration, Mr. Petty utilized the near field/far field model where in this case the far field component was not factored into the final assessment. The near field is defined as the zone immediately surrounding the individual. In cases where there is basically a single point source for the contaminant to be released into the breathing zone (near field), a hemisphere is normally used to represent the breathing zone of the individual with a radius of arms length of 0.78 meters (2.5 feet).[41] The concentration within that hemisphere is a function of the generation rate of the contaminant and the air movement in and out of that hemisphere. Mr. Petty assumed an air speed of 37.5 fpm through the near field.

Mr. Petty used a radius of the near field of less than half a meter (0.457m) based upon the conversation he had with the plaintiff. According to the telephone log, the plaintiff claimed to

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[41]Keil, C. B., "Mathematical Models for Estimating Occupational Exposure to Chemicals," AIHA, 2000 pg 53.

have been between 6 inches to 18 inches away from the Liquid Wrench wetted materials. Mr. Petty assumed all the benzene in the Liquid Wrench evaporated into the air less the amount of benzene that was absorbed via his dermal flux model. Based on his conversation with Mr. Knapper, he assumed a post application wet time of two hours. This resulted in all the benzene evaporating from the solvent following the product application after approximately two hours to two hours and 25 minutes.

Mr. Petty calculated the generation rate of benzene evaporating from the Liquid Wrench by dividing the mass of benzene available to evaporate by the cumulative time of each event.

Mr. Petty's Dermal Methodology

To calculate the dermal exposure, Mr. Petty utilized a dermal flux model. This model calculated the amount of benzene absorbed through the skin based on a flux value (the amount of material that absorbs through the skin per the amount of surface area exposed per unit of time). As noted in this report dermal dose calculations are not added to inhalation dose calculations for comparison with occupational health standards, i.e., the OSHA PEL.

Even if dermal flux exposure estimation models had been validated, Mr. Petty's development of an equation to predict flux values for mixtures containing variable volumes of benzene has not been validated, has no known error rate and is therefore unreliable. This approach does not address the differences in exposures based on personal factors (individual differences) nor does it address factors associated with the exposure environment (environmental factors such as temperature, airflow across the skin surface, etc.). Most significantly, Mr. Petty's equation does not reflect the differences in flux based on the solvent (product) vehicle or combination of other chemicals in the mixture, especially as it effects permeation and evaporation rates.

Mr. Petty selected a few measurements from four studies[42,43,44,45] while ignoring other studies.[46,47,48] Furthermore, he omitted some data points in the studies he quoted. Inclusion of the omitted values changed the equation. Even if the equation accurately reflected the available data or was censored in a scientifically and statistically valid manner, Mr. Petty's equation yielded values that differ from experimentally derived values from 9% to more than 1,000%, see Appendix V. I used the Blank and McAuliffe (1985) data to perform this simple reality check. As Table VI demonstrates, Mr. Petty's equation was used to estimate flux values for four solutions each containing five percent (5%) benzene. Blank and McAuliffe reported experimental values for each of these five percent benzene mixtures. The Blank and McAuliffe article demonstrated the statistical unreliability of determining flux values for benzene in solvent

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42 Hanke et al 1961.

43 Fiserova-Bergerova V and Pierce JT. "Biological Monitoring V: Dermal Absorption." Applied Industrial Hygiene, 4 (1989): F-14 - F-21.

44 Blank, I.H., and D. J. McAuliffe. "Penetration of Benzene through Human Skin." J. Invest. Dermatol, 85 (1985): 522-526.

45 Susten, et. al. "Percutaneous Penetration of Benzene in Hairless Mice: an Estimate of Dermal Exposure During Tire Building Operations." American Journal of Industrial Medicine, 7 (1985): 323-335.

46 Adami, et al. "Penetration of benzene, toluene and xylenes contained in gasolines through human abdominal skin in vitro." Toxicology in Vitro, 20 (2006): 1321-1230.

47 Franz 1984.

48 Loden, M. "The in vitro Permeability of Human Skin to Benzene, Ethylene Glycol, Formaldehyde, and n-Hexane." Acta Pharmacol. et Toxicol., 58 (1986): 382-389.

mixtures. Mr. Petty used the Blank and McAuliffe study without regard for the scientific limitations of such data.

Table VI: Comparison of Experimentally Measured Values and Petty Predictions

Reference:	% Benzene in Mixture	Flux predicted by Petty Equation*	Measured Flux Reported in Study (mg/cm^2-hr)	Percent Error
Blank and McAuliffe, 1985	5% in gasoline	0.05155	0.062	16.9%
Blank and McAuliffe, 1985	5% in hexadecane	0.05155	0.047	9.7%
Blank and McAuliffe, 1985	5% in hexane	0.05155	0.105	50.9%
Blank and McAuliffe, 1985	5% in isooctane	0.05155	0.187	72.4%

* Petty, Stephen. Outline of opinions Liquid Wrench benzene exposure Lewis E Knapper Case prepared for Heard Robins Cloud & Lubel, LLP, May 20, 2009 p. 31. Eq. (7-5) **$Flux_b$ = 0.0183 (% Benzene Conc.)$^{0.6435}$** based on based on six (6) values from four (4) articles: Hanke et al 1961, Fiserova-Bergerova 1989, Blank et al 1985, and Susten et al 1985. Note Isooctane value from Blank and McAuliffe was not included in Petty estimate.

$$\text{Percent error} = \frac{|\,\text{value} - \text{value}_{\text{approximate}}\,|}{|\text{value}|}$$ [49]

Mr. Petty's Assumptions regarding Mr. Knapper's Exposure to Liquid Wrench

Mr. Petty assumed the duration of exposure to Liquid Wrench was between approximately two hours and two hours and 25 minutes per event (application time plus two hours of wet time). The basis of Mr. Petty's assumption is as follows, "An ETpa value [time wet after application] of 2 hours was used throughout the time he used Liquid Wrench based on the average of 0 – 4 hours of time before lunch or when he likely washed at home." According to Mr. Petty's telephone log, "Mr. Knapper indicated in Appendix B [Petty Report] that product stayed on his hands until it dried." Mr. Knapper described the feeling of Liquid Wrench in his hands in his deposition taken 13 January 2009 as, "It was cool. It seemed like it was in—it would evaporate fast, and it would dry on my hands, chap them up." The plaintiff's description of Liquid Wrench evaporating fast contradicts Mr. Petty's assumption that the benzene in the Liquid Wrench would remain wet on Mr. Knapper's skin for over two hours for each application or event.

The number of events for each work activity, assumed by Mr. Petty was taken either from the telephone log of the plaintiff, or was assumed to occur once per week for certain employer based activities. The duration in years or months was taken from the telephone log of the plaintiff.

Mr. Petty assumed all the Liquid Wrench that Mr. Knapper used during his lifetime was the raffinated version of this product. According to Mr. Knapper's deposition testimony, he used only the eight ounce drip cans of Liquid Wrench. He recalled seeing a skull and crossbones on some of the cans of Liquid Wrench that he used. These Liquid Wrench cans would have been the raffinated version of Liquid Wrench according to James Wells, corporate representative for

49 Golub, Gene; Charles F. Van Loan (1996). Matrix Computations - *Third Edition*. Baltimore: The Johns Hopkins University Press. pp. 53.

Radiator Specialty.[50] Mr. Knapper also identified a can of Liquid Wrench that did not contain the skull and crossbones as a Liquid Wrench product he used. This Liquid Wrench can would have been the non-raffinated version of Liquid Wrench.[45] Mr. Knapper could not delineate how much of the raffinated version versus the non-raffinated version of Liquid Wrench he used in the 1960s and 1970s.[51] Therefore, if Mr. Knapper used the non-raffinated version of Liquid Wrench for some of the applications in the 1960s and 1970s, Mr. Petty's estimate of Mr. Knapper's exposure to benzene would have been overestimated.

Mr. Petty's Assumptions Regarding Mr. Knapper's Dermal Exposure to Liquid Wrench

When evaluating Mr. Petty's evaporation rate of benzene in Liquid Wrench for the dermal exposure, his average concentration of benzene in Liquid Wrench for the two hour time frame after the application of Liquid Wrench was 3.1% (v/v). This is more than 50% of the of the original benzene concentration in Liquid Wrench from the time Mr. Knapper would apply the product.

Mr. Petty assumed no evaporation of benzene from the Liquid Wrench during the application period of approximately five (5) minutes to 25 minutes. He then applied an exponential evaporation rate constant[52] to determine the average benzene concentration in Liquid Wrench over the next two hours that would be on Mr. Knapper's skin. The basis for this evaporation rate constant that Mr. Petty used is not scientifically reliable. To arrive at this evaporation rate constant, Mr. Petty plotted an exponential decay curve from benzene evaporating from the Exxon Valdez crude oil spill in Alaska. The air and water temperature were approximately 3 degrees centigrade (37 degrees Fahrenheit). He plotted the evaporation rate curve for crude oil and for gasoline and concluded that benzene evaporated from crude oil at a different rate than crude oil or gasoline.

Mr. Petty plotted a curve based upon the evaporation rate for Liquid Wrench and compared that to the evaporation rate for gasoline and for crude oil and concludes that Liquid Wrench evaporated faster than crude oil and slower than gasoline. Mr. Petty then concluded that the rate at which benzene evaporated from Liquid Wrench would be the average of the half-life of crude and the half-life of gasoline. He then took this value to calculate the alpha for benzene evaporating from Liquid Wrench. The evaporation rate of a compound such as benzene as compared to the evaporation rate for a mixture are two distinct independent scenarios.

Evaporation rates of benzene from a solvent mixture are dependant on various factors such as air speed, surface area exposed, amount of benzene in mixture, temperature of the solvent mixture, the other constituents in the mixture (van der Waals forces), and many other factors. To calculate the percentage of benzene lost or remaining in the solution over a period of time depends on the above factors including the mass of the solvent and the thickness of the solvent

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50 Affidavit of James D. Wells, signed 14 October 2008.

51 Deposition of Lewis Knapper, taken 14 January 2009, pgs. 82-84

52 Mr. Petty obtained an exponential evaporation rate constant, α, from averaging the evaporation rate he obtained from benzene evaporating from crude oil and the evaporation rate of gasoline.

dispersion. Mr. Petty applied his evaporation rate constant to determine what the average percent concentration of benzene would be over the post application period of two hours but does not take into consideration these factors in making his evaporation rate calculation. Therefore his benzene concentration in Liquid Wrench is unreliable.

Mr. Petty assumed that Mr. Knapper made dermal contact with the Liquid Wrench immediately upon the dispensing of the product. He assumed that the Liquid Wrench would have covered the entire right hand surface area, front and back and at least one-half of the surface area of the left hand, plus part or all of the wrist surface area immediately upon the dispensing of the product every time Mr. Knapper used Liquid Wrench. Mr. Petty also assumed that the contacted areas would remain wet for an additional two hours after the dispensing of the Liquid Wrench. Based on the normal and typical use of Liquid Wrench, a worker would not cover the entire surface area of the palms, fingers, and back of the hand every time they used the product.

Mr. Knapper testified that he would get Liquid Wrench on his hands; However, the amount of Liquid Wrench he would get on his hands would vary. He also stated when he used the Liquid Wrench on his bike, he would get Liquid Wrench only on the front side of his hands. Testimony from a worker in another case who used Liquid Wrench stated that he got Liquid Wrench on his hands less than 50% of the time when he used the product. When he did get Liquid Wrench on hands, it would be only on the fingers and palms of his hands. Another worker that used Liquid Wrench stated that he may have gotten a drop or two on himself, but he explained that normally one could use Liquid Wrench and not get any on their hands at all. This worker also testified that he never got Liquid Wrench all over the palm of his hand or on all five fingers.[53]

As indicated in his testimony, Mr. Knapper did not get Liquid Wrench immediately upon dispensing the liquid over all the surfaces areas as depicted by Mr. Petty. There may have been occasions where Mr. Knapper did get Liquid Wrench over the skin surface area as outlined by Mr. Petty. However it would not have happened every time and when it did happen it would have been most likely after the waiting period to allow the Liquid Wrench to work before handling the product. Testimony by Mr. Knapper indicated that he would apply the Liquid Wrench and wait up to 15 minutes before attempting to remove the bolts or fittings.[54] During this delayed time period, most if not all of the benzene would have evaporated from the Liquid Wrench thereby reducing, or eliminating the potential absorption of the benzene through the skin. Mr. Petty's assessment of the dermal absorption is a significant overestimation of exposure dose.

It is not logical for someone to get Liquid Wrench on both hands and try to remove bolts using a wrench since the Liquid Wrench has an oil base, making the wrench slippery and difficult to hold. If a worker did get Liquid Wrench on his hands, generally, the worker would wipe his hands to remove as much of the Liquid Wrench as possible. According to Mr. Coleman, a co-worker of Mr. Knapper, he believed that Liquid Wrench was oily. When asked when he got Liquid Wrench in his fingertips, did he wipe it off to get a better grip, Mr. Coleman responded, "We always carried rags with us for that purpose. Yes." Mr. Coleman said that Mr. Knapper

53 Deposition of Robert Burton, taken 19 Sept 2008 and Deposition of Edson Burnham, taken 2 Oct 2008 in the Robert B. Oakley and Irene Oakley v. Radiator Specialty, Case Number 2:07-CV-00351.

54 Deposition of Lewis Knapper, taken 13 January 2009, pgs. 24-26.

carried rags for that purpose also.[55] If Mr. Knapper wiped his hands to remove as much of the Liquid Wrench as possible when he got it on his hands, the duration of exposure and resulting calculated absorbed dose would be less than what Mr. Petty's two (2) hour plus dermal exposure assessment predicted.

Regarding the surface area of the average male hand, Mr. Petty selected the EPA 50th percentile value of 990 cm^2 instead of the mean value of 840 cm^2 referenced by the EPA for assessing exposure of the hands to a chemical.[56] By selecting the 50th percentile instead of the mean value in his calculation would result in an increase the dermal absorption or overestimate the absorption by the hands by approximately 18 percent.

Mr. Petty's Assumptions Regarding Mr. Knapper's Inhalation Exposure to Liquid Wrench

When Mr. Petty calculated Mr. Knapper's inhalation exposure to Liquid Wrench, he calculated the exposure based upon all the benzene in the Liquid Wrench, less the amount dermally absorbed, being evaporated within the two hours plus timeframe for each event.

Mr. Petty assumed that the benzene concentration in the Liquid Wrench would remain at 5.4% for the first approximately 5 to 25 minutes during his dermal calculations and then would decrease based on his alpha (defined as an exponential evaporation rate constant used in Mr. Petty's average concentration formula) discussed above. In Mr. Petty's report, he stated, "During the application of products containing benzene, the benzene evaporates from application location within arms length of the worker's breathing zone." One cannot have a situation with both "no loss of benzene from the Liquid Wrench" while at the same time "having loss of benzene" when the liquid is evaporating from the equipment and from the hands.

Mr. Petty chose the radius of the near field hemisphere (or distance to the point of evaporation) to be 0.457 meters or approximately 18 inches based upon the plaintiff's testimony in Mr. Petty's telephone log. This value is uncharacteristically small and it is unrealistic to assume that Mr. Knapper's nose and mouth were within 18 inches of the application point of the Liquid Wrench for the entire two hour plus duration of exposure per event. Using Mr. Petty's arm's length for the radius of the hemisphere or distance from the application point would result in a conservative value of 30 inches.[57] This corrected value for the radius resulted in a significant (approximately 60%) reduction in the airborne concentration of benzene in the near field and resulting cumulative dose.

Mr. Petty depicted the loss of benzene from Liquid Wrench as an exponential decay curve described earlier. Mr. Petty assumed that all the benzene evaporated from the Liquid Wrench in the two hour plus time frame described earlier. However, Mr. Petty lacked sufficient detail on the usage of Liquid Wrench by Mr. Knapper while he was working at the Citgo Service Station; when he worked at Jackson's Garage, when Mr. Knapper worked as a plumber's helper and plumber in New York and Texas; and when he rebuilt cars using Liquid Wrench in Texas and

55 Deposition of Ronald Coleman, taken 30 April 2009.

56 U.S. EPA, National Center for Environmental Assessment, Exposure Factors Handbook, August 1997.

57 Jurgens, H. W., et al., "International Data on Anthropometry," Occupational Safety and Health Series No. 65, 1990, pg. 22.

New York. In these cases, Mr. Petty assumed that an entire can evaporated in the two hour plus time frame for each use of Liquid Wrench. For example, based upon the testimony of Mr. Knapper, he would use a can of Liquid Wrench per week for all his work completed for the week. The actual amount of Liquid Wrench used per event or activity is unknown, therefore Mr. Petty's airborne exposure concentration calculation would not be representative of the actual airborne concentration for benzene that Mr. Knapper was exposed to during these activities.

The evaporation rate of benzene from the Liquid Wrench is dependant upon various factors defined above. Based upon the results of the study conducted by EPI to evaluate the evaporation rate of benzene from Liquid Wrench, the benzene would have completely evaporated in approximately 15 minutes or less after the product application.

Tables VII and VIII presents a summary of Mr. Petty's assumptions he used in his exposure assessment and the corrected value I used to assess Mr. Knapper's benzene exposures during his use of Liquid Wrench.

Table VII: Plaintiff's Industrial Hygiene Expert Assumptions and Corrected Input Values (Part 1: Dermal Exposure Factors)

Category of Input Values	Petty Assumptions or Input Parameters	Corrected Values
Exposure duration per application/event	5-25 min. + 120 min = 125-145 min. Assumes right hand wet for entire time, left hand wet 50% of the time, wrists wet 25%-50% of the time plus face and forearms during some activities are wet. Based on telephone log with Mr. Knapper.	EPI Evaporation Rate Study concluded the benzene would be gone in 15 minutes after application. Therefore, 20 min. time assigned for dermal absorption.
Number of events	Used 100 events over a four year period for repair of motorcycles.	Mr. Knapper's deposition testimony taken 13 January 2009 page 41 stated he worked on 50 motorcycles in this time frame.
Surface area of skin	- Uses EPA 50th percentile surface area of male hand 990 cm^2 -Assumes all surface area contacted is immediately wet and stayed wet for entire event duration.	- EPA mean value for male hand is 840 cm^2
Skin Absorption factor	Fingers, forearm, face, wrists = 1, Palms = 2 Federal Register. Assumes 1.5 for entire hand.	The palm represents 225 cm^2 of Mr. Petty's 990 cm^2, so the correct factor for the entire hand should be $\frac{(225 \times 2) + (990-225) \times 1}{990} = 1.2$ However EPI used the same value as Mr. Petty - Susten 1985 identified the palmer surface area to be 225 cm^2. Based upon Modjtahedi & Maibach, the ratio is 2:1 for pure benzene on palms. Rates for absorption of benzene through the skin are affected by the mixture.
Evaporation rate	Depicts benzene evaporating from crude oil and Liquid Wrench as an exponential decay curve. Averages the evaporation rates of benzene from crude oil and gasoline to derive evaporation constant for benzene in Liquid Wrench, used in dermal calculation. Uses 5.4% for 5-25 min. exposure with no loss of benzene, then calculates average concentration over next two hours to be 3.1%.	Based upon EPI's Benzene Evaporation Rate Study, the average concentration of benzene in Liquid Wrench over 20 minutes was 1.04%. The evaporation of benzene would have been immediate, not delayed for 5-25 minutes.
Flux	0.0542 mg/ cm^2-hr application time 0.03747 mg/ cm^2-hr Post application time	0.019 mg/ cm^2-hr This value was derived using Mr. Petty's flux equation

Cumulative impact of corrected values reduces Mr. Petty's estimate by > 90% to 2.7 ppm-years

Table VIII: Plaintiff's Industrial Hygiene Expert Assumptions and Corrected Input Values (Part 2: Inhalation Exposure Factors)

Category of Input Values	Petty Assumptions or Input Parameters	Corrected Values
Generation rate	Petty states typically the time for the liquid (benzene from LW) to evaporate is equal to the activity time. It is conventional in exposure calculations to use 100% benzene mass evap. from LW during these NF exposure calculations. [Spencer 2007]	The assumption of all the benzene evaporation during the activity time is assuming a worst case scenario or maximum exposure.
Near Field Zone	Assumes arm's length for his near field radius factor of 18" or 1.5 feet or .46 meters Near field volume = 0.20 m3 Surface area NF zone = 1.31m2 Vol. Flow in & out NF = 7.51m3/min Assumes all the benzene in the Liquid Wrench evaporates within 2 hour plus time frame into the near field.	Per International Data on Anthropometry, the forward reach of the 5th percentile male was 2.6 feet. Per Das and Grady, Industrial Workplace Layout Design, Table 2 the 50th percentile arm reach is 2.5 feet. Near field volume = 0.93 m3 Surface area NF zone = 3.65m2 Vol. Flow in & out NF = 20.85 m3/min
Exposure Duration	Mr. Petty assumes that Mr. Knapper was within the near field for the entire duration of the exposure event for every event for his entire lifetime, e.g. 2+ hours.	Assuming Mr. Knapper was within the near field for the entire duration of the event for each and every event is unlikely and portrays a worst case scenario.
Number of events	Used 100 events over a four year period for repair of motorcycles.	Mr. Knapper's deposition testimony taken 13 January 2009 page 41 stated he worked on 50 motorcycles in this time frame.
Vapor emission rate	Assumes the dispensed amount or an entire can of Liquid Wrench is evaporated over the event time period. The total available mass of benzene is divided by the total time in minutes to develop a generation rate.	Mr. Petty did not know the actual time Mr. Knapper spent for each event or activity, Mr. Petty assumed a value of 2 hours plus application time. So the generation rate and resulting airborne concentration for benzene calculated by Mr. Petty is not relevant to Mr. Knapper's actual airborne concentration of benzene exposure.
Cumulative impact of corrected values reduces Mr. Petty's exposure estimate by >60% to 0.8 ppm-years		

Mr. Petty's Assumptions Regarding Mr. Knapper's Dermal Exposure to Safety-Kleen Solvent

Mr. Petty assumed that the Exxon Varsol benzene concentrations are representative of the benzene concentration in the Safety-Kleen solvent during the time period that Mr. Knapper would have used the Safety-Kleen parts washers.

Mr. Petty assumed that each and every time Mr. Knapper used a Safety-Kleen parts washer, it contained 0.03% benzene (300 ppm), the level of benzene in fresh solvent based upon the Exxon Varsol data. Parts washer solvent was not replaced every day, but more likely every month or longer depending on usage rates. If the assumption was that solvent was replaced daily and that Mr. Knapper used the parts washer at some point during the day, the starting concentration, on average, based upon the benzene concentration assumed by Mr. Petty would have been 0.017%.

This is based upon the change in benzene concentration in the parts washer solvent over time. Mr. Knapper could have used the parts washer at anytime beginning in the morning to late in the day. The average concentration at t = four hours (half way through the day) would be 0.017% using the following formula and the half-life alpha derived from Fedoruk et al., (2003), the same alpha that Mr. Petty used in his calculations.[58,59]

$$C(t) = C(o) \times \exp(-\alpha x t)$$

Table IX presents a summary of the assumptions Mr. Petty used in his exposure assessment and the corrected value I used to assess Mr. Knapper's benzene exposures during his use of Safety-Kleen Solvent.

Table IX: Dermal Exposure Model Input Values used by Mr. Petty and Corrected Values for Safety-Kleen Solvents

Category of Input Values	Mr. Petty's values	Corrected values
Exposure Duration per job	For tank at Colintonio, Citgo Garage and ½ time at Jacksons Garage, assumed 3 hours wet time after removing hands from tank.	Unlikely for benzene to remain in residual solvent for 3 hours after removal from tank. No changes made in calculation.
Number of events	Colintonio, 31 events. Assumed used tank 1x/day for 4.17 wks/month x 1.5 months = 31	Per deposition testimony of Mr. Knapper taken 13 January 2009, pgs.46-47, Mr. Knapper used the solvent tank 1x/week for 6.26 weeks per Petty calculation for total events of 6.26.
Surface area of skin in contact with LW	990 cm^2 per hand	840 cm^2 hand
Flux	0.0019 mg/ cm^2-hr while working in the tank 0.00168 mg/ cm^2-hr after removing hands from tank	0.00133 mg/ cm^2-hr while working in the tank 0.00117 mg/ cm^2-hr after removing hands from tank
Concentration of benzene in Liquid Wrench during exposure period	0.03% first 30 minutes 0.0245% average last 180 minutes	0.017 %* average for first 30 minutes, 0.014 %* for remaining time
Cumulative impact of corrected values reduces Mr. Petty's exposure estimate by >60% to 0.4 ppm-years		

*This value was derived using Mr. Petty's average concentration equation

58 http://wikipedia.org/wiki/Exponential_decay

59 Fedoruk, M. J., "Benzene Exposure Assessment for Use of a Mineral Spirits-Based Degreaser," Applied Occupational and Environmental Hygiene, 2003.

Mr. Petty did not conduct an inhalation exposure assessment regarding Mr. Knapper's alleged use of the Safety-Kleen product.

EPI Exposure Assessment

Air monitoring for determination of employee exposure is presently the only method accepted by OSHA for evaluating compliance with occupational health standards. When personal air monitoring data is not available for the individual, the use of data from co-workers or surrogate data from other operations may be used, with caution, to provide some basis for estimating potential exposures. When air monitoring data is not available, then exposure estimates can be made by mathematical modeling. A concern with relying on a model is its validation, which has been previously discussed. The Near Field/Far Field Model has been validated in several studies which Mr. Petty used to calculate his estimate of Mr. Knapper's lifetime airborne exposure to Liquid Wrench. The Dermal Flux Model however has not been validated.

If we proceed with Mr. Petty's approach to estimating Mr. Knapper's cumulative exposure to benzene using the Near Field/Far Field Model and the Dermal Flux Model but change the input parameters due to Mr. Petty's improper assumptions, we arrive at a radically different but more representative estimation of Mr. Knapper's cumulative exposure to benzene from use of Liquid Wrench and Safety-Kleen products.

Mr. Knapper's Potential Exposure to Benzene from Liquid Wrench

Assuming that Mr. Petty's methodological approach to dermal and inhalation exposure to benzene in the Liquid Wrench was correct, and correcting the input parameters used by Mr. Petty that are incorrect, Mr. Knapper's dermal exposure would be approximately 2.7 ppm-years and the inhalation exposure would be approximately 0.8 ppm-years.

A second analysis was completed with only the exposure duration and flux changed (these values were changed based upon the EPI Evaporation Rate Study) in Mr. Petty's dermal and inhalation models. The resulting dermal exposure would be approximately 3.0 ppm-years and the inhalation exposure would be approximately 2.3 ppm-years.

Mr. Knapper's Cumulative Airborne Exposure Estimate to Benzene from Liquid Wrench

The cumulative exposure to benzene in air from Liquid Wrench is based upon the following factors:

- Average concentration of benzene in the breathing zone of Mr. Knapper.
- Duration of exposure to that concentration in air.

The concentration in the near field (breathing zone) is defined by the radius of the near field, the air flow in and out of the near field and the amount of benzene released into the air per minute. It is very unlikely that Mr. Knapper stayed within a half a meter of the Liquid Wrench wetted

materials for the two hour plus time frame for every event he completed in his entire working career and every event he completed in his leisure time. A more reasonable value to use as the radius in the Near Field model was the approximate length of the arm in front of the torso, or 2.5 feet (0.762 meters). As described by Mr. Petty, "During the application of products containing benzene, the benzene evaporates from application location within arms length of the worker's breathing zone." This is still a very conservative value and still assumes Mr. Knapper would have remained within this distance to the Liquid Wrench wetted surface for the entire time it took for all the non-absorbed benzene to evaporate. When the correct value for the radius of the near field is entered into the model and the maximum length of exposure time that Mr. Knapper potentially worked with raffinate containing Liquid Wrench, the resultant cumulative exposure is 0.8 ppm-years. Appendix VI contains the summary page of the spreadsheets used to calculate this cumulative inhalation exposure.

Mr. Knapper's Cumulative Dermal Exposure Estimate to Benzene from Liquid Wrench and Safety-Kleen Solvent

The cumulative exposure to benzene on the skin from contact with Liquid Wrench according to Mr. Petty is determined by the following factors.

- The average concentration of benzene in the Liquid Wrench or Safety-Kleen solvent over the contact period of time
- The surface area of skin contacted
- The location of the skin contacted e.g. fingers vs. palm
- The exposure duration

The average concentration of benzene in the Liquid Wrench over the 20 minute time period would be 1.04 %; the surface area of the skin contacted for the hands would be 150 cm^2 less per whole hand; Mr. Petty's skin factor of 1.5 was used for the hands (Mr. Petty assumed a 1.5 factor based upon the combination of absorption through the palm - absorption factor of two and through the other parts of the hand - absorption factor of one); and the duration of contact where benzene could be absorbed would be 20 minutes per event. When considering these values and the adjusted flux based upon benzene concentration using Mr. Petty's formula below, and the maximum length of exposure time that Mr. Knapper potentially worked with raffinate containing Liquid Wrench, the resultant cumulative exposure would be 2.7 ppm-yrs. Appendix VII contains the summary page of the spreadsheets used to calculate this cumulative dermal exposure.

$$\text{Flux} = 0.0183\ (\%\ \text{benzene})^{0.6435} \qquad \text{(Petty formula)}$$
$$= 0.019\ \text{mg/ cm}^2\text{-hr}$$

The average starting concentration of benzene in the Safety-Kleen solvent assuming the tank is filled with fresh solvent each day is 0.017% and 0.014% over the next three hours. The surface area of the skin contacted for the hands would be 150 cm^2 less per whole hand. Mr. Petty's skin factor of 1.5 was used for the hands, and the duration of contact where benzene could be absorbed would be 30 minutes in the tank and 180 minutes after removing the hands from the tank. When considering these values and the adjusted flux based upon benzene concentration using Mr. Petty's formula below, the resultant cumulative exposure would be 0.4 ppm-yrs.

Appendix VIII contains the summary page of the spreadsheets used to calculate this cumulative dermal exposure.

$$\text{Flux} = 0.0183\ (\%\ \text{benzene})^{0.6435} \qquad \text{(Petty formula)}$$
$$= 0.017\ \text{mg/ cm}^2\text{-hr and } 0.014\ \text{mg/ cm}^2\text{-hr}$$

The exposure values derived by EPI are believed to be reasonable upper bound estimates based on the testimony, scientific literature, and the use of Mr. Petty's methodology. Additional factors not considered in the upper bound estimates that would reduce these estimates even further would include the following:

- If dermal contact was not immediate after the dispensing of the Liquid Wrench.
- If the total surface area estimated by Mr. Petty was not wetted immediately upon the dispensing of the Liquid Wrench but occurred during the removal and handling of the work pieces.
- If Mr. Knapper used a rag to wipe the Liquid Wrench off of his hands after dermal contact with the Liquid Wrench.
- If some of the Liquid Wrench used by Mr. Knapper was the non-raffinated version of Liquid Wrench.
- If the solvent in the Safety-Kleen tanks was not changed on a daily basis, but on the more likely monthly schedule.

Conclusions

Based on my review of documents and scientific literature to date, my review of Mr. Knapper's work history as described in his testimony, and on my professional experiences, it is clear to me that the airborne concentration of benzene vapor, if any, from the use of Liquid Wrench and Safety-Kleen Solvent would not have exceeded the OSHA-PEL or 15-minute STEL at the time of the product use.

1. Using the plaintiff's industrial hygiene expert's methodology for determining inhalation exposure resulted in a cumulative inhalation dose to benzene-containing Liquid Wrench of 0.8 ppm-yrs. The cumulative exposure was well below the health standards of the day and even current day standards.
2. The plaintiff's industrial hygiene expert's methodology for determining dermal dose has not been scientifically validated, is not reliable, nor is it a standard and acceptable industrial hygiene practice for quantifying dermal dose.
3. When developing the occupational health standards and guidelines, OSHA and other standard and guidelines setting agencies accounted for the dermal route of exposure and used the inhalation route of exposure as the surrogate for both dermal and inhalation exposures.

4. The Liquid Wrench product labels met the requirements of the FHSA regulations during the period of time from 1960 to 1978 and conveyed the necessary information for Mr. Knapper to properly manage the hazards of the product.

My opinions are based on my more than 32 years of experience as an industrial hygienist and safety professional. My experience has included health hazard evaluations and audits of multiple operations within facilities similar to and the same as those workplaces experienced by Mr. Knapper. My experience has also included the development of exposure assessment strategies, and training of employees who worked in numerous industrial operations. I also base my opinion upon portions of the scientific literature focused on occupational health hazard assessment.

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127. Plaintiff's Notice of Initial Disclosures
128. Plaintiff's First Supplemental Case Specific Disclosures
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130. Plaintiff's Notice of Supplemental Disclosures
131. Plaintiff's Additional Disclosures
132. Plaintiff's Initial Disclosures
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140. Semple, S. "Dermal Exposure to Chemicals in the Workplace: Just how important is skin absorption? *Occupational and Environmental Medicine,* **61** (2004): 376-382.
141. Spencer, J. "Exposure Assessment: An Evaluation of Benzene from the Application and Use of a Prepared Liquid Wrench Solvent in Static Environmental Conditions." EPI Study Report, 27 September 2002.
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149. U.S. Environmental Protection Agency. Risk Assessment Guidance for Superfund – Volume 1 – Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), EPA/540/R99/005. July 2004.
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151. Van de Sandt, JJM, Dellarco, M, and van Hemmen JJ. "From dermal exposure to internal dose." *Journal of Exposure Science and Environmental Epidemiology*, **17** (2007): S38-S47.
152. van Hemmen et al. RiskofDerm: Risk assessment of occupational dermal exposure to chemicals. An introduction to a series of papers on the development of a toolkit. *Annals of Occupational Hygiene,* **47**(8): 595-598, 2003.
153. Various occupational safety and health publications and articles developed by government agencies, professional and trade associations, voluntary consensus standards organizations, and researchers.
154. Various state and federal occupational safety and health legislation and/or regulations.

155. Williams, et al. "Airborne Concentrations of Benzene Associated with the Historical Use of Some Formulations of Liquid Wrench." *Journal of Occupational and Environmental Hygiene* 4 (2007): 547-561.
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My report is based on the information available to me at this time. Should additional information become available, I reserve the right to determine the impact, if any, of the new information on my opinions and conclusions, and to revise my opinions and conclusions if necessary.

Sincerely,

John W. Spencer, CIH, CSP
President

JWS/ddj

Appendices:

APPENDIX I:	Curriculum vitae John W. Spencer, CIH, CSP
APPENDIX II:	Benzene Dermal Flux Data for Various Liquid Mixtures Containing Variable Benzene Levels
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APPENDIX I:

Curriculum vitae
John W. Spencer, CIH, CSP

EPI

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CURRICULUM VITAE

JOHN W. SPENCER, CIH, CSP

Date of Birth:	12 February 1954
Citizenship:	USA

Education:

1980-1981	National Institute for Occupational Safety and Health and OSHA Training Institutes – Special Programs
1973-1976	B.S. Biological Sciences University of Maryland College Park, Maryland
1972-1973	St. Mary's College St. Mary's City, Maryland

Professional Experience:

1993 - Present	President Environmental Profiles, Inc. Columbia, Maryland
June 1990 - 1993	Vice President and Director of Environmental Sciences National Medical Advisory Service Bethesda, Maryland
1988-1990	Principal Daft-McCune-Walker, Inc. Towson, Maryland President DMW Environmental Services, Inc. a subsidiary of Daft-McCune-Walker
1987-1988	Corporate Industrial Hygienist and Environmental Coordinator United States Fidelity and Guarantee Company Baltimore, Maryland
1982-1987	Director of Industrial Hygiene and Occupational Health Programs United States Coast Guard, 5th District Portsmouth, Virginia

Professional Experience (cont.):

1980-1982	Team Leader/Industrial Hygienist National Institute for Occupational Safety and Health National Occupational Hazard Survey Cincinnati, Ohio
1977-1980	Industrial Hygienist Equitable Environmental Health Rockville, Maryland

Certifications and Registrations:

1987	American Board of Industrial Hygiene Certified Industrial Hygienist
1991	Board of Certified Safety Professionals Certified Safety Professional
2003	Certified Indoor Air Quality Consultant

Professional Societies:

	American Indoor Air Quality Council
	American Industrial Hygiene Association
	American Board of Industrial Hygiene
	American Conference of Governmental Industrial Hygienists
	Board of Certified Safety Professionals
	American Association for the Advancement of Science
	Society for Chemical Hazard Communication
1999	Member, American Society of Safety Engineers
1998	Member, American Association for the Advancement of Science
1996	Member, New York Academy of Sciences
1993-94	Member, Maryland Industrial Hygiene Council
1992-93	President, American Industrial Hygiene Association, Chesapeake Section
1992	President-Elect, American Industrial Hygiene Association, Chesapeake Section

Committees:

American Industrial Hygiene Association:
Product Health and Safety Committee (1991-1995)
- MSDS and Labeling and other Warning Issues
Emergency Response Planning Committee (1991-1999)

Awards:

1987	USF&G Company Excellence Through Service Award
1976	National Institutes of Health Outstanding Achievement Award

Selected Project Management Experience:

2001	Director of health, safety, and environmental management for a ship recycling firm. Managed the proper removal of asbestos, PCB, mercury, lead, petroleum products, and other regulated substances.
1997	Planned and conducted facility audits for health and safety regulatory requirements and Voluntary Protection Programs elements. Completed eleven (11) facilities in a three-week period using in-house developed software auditing and tracking tools.
1994-1996	Developed and implemented exposure assessment strategies of film processing operations. The operations included mass color film processing, and color film processing during the operation of a minilab. Investigations have also included the review of potential chemical exposures resulting from the use of X-ray development equipment in private doctors' offices and hospital environments.
1994	Conducted oversight of the environmental clean up of a U.S. naval aircraft carrier during a shipbreaking process. Evaluated for contaminated waters, painted surfaces, PCB, and asbestos containing materials. Insured the proper removal and disposal of all waste materials.
	Developed product warning labels and material safety data sheets for industrial and consumer products.
	Managed the final clearance of asbestos from approximately 25 occupied apartment buildings. Oversaw clean-up strategy, including air monitoring of work and adjacent spaces.

Selected Project Management Experience (cont.):

1994	Have conducted numerous indoor air quality investigations of commercial office space, clinical laboratories, and on University campuses. Assessments included review of the heating ventilating and air condition system, management programs to respond to IAQ complaints and real time monitoring for chemical, physical, and biological agents.
1994	Conducted audits of health, safety, environmental and management programs of multiple chemical processing facilities.
1991, 1992, 1993	Designed and implemented several comprehensive product risk analysis evaluations for product manufacturers. Analysis included hazard identification, toxicological assessments, industrial hygiene exposure assessment, and risk characterization. Recommendations to control or eliminate potential user exposures were provided.
1991, 1992, 1993	Supplemental information for product warnings by the MSDS, labels, and technical information bulletins was also included.
1990, 1991, 1993	Provided expert opinion on sufficiency of labels and warnings for chlorinated solvents, isocyanate, and benzene containing products.
1989	Evaluated a 450-acre manufacturing facility with nearly 3 million square feet of manufacturing and warehouse space for hazardous substances which may have represented liability to the potential purchaser under CERCLA. Reported directly to the Rouse Company in Columbia, Maryland as their environmental advisor for the approximate $43 million property transfer.
1988-1990	Have conducted numerous exposure assessments to evaluate actual personal exposure levels that resulted from various workplace tasks and environments. Benzene, asbestos, formaldehyde, chlorinated solvents, and automobile by-products of combustion were evaluated via real-time assessments to assess actual personal exposures.
1988-1989	Developed a groundwater monitoring and protection program for a new golf course facility. Determined environmental base line parameters to be applied to subsequent future groundwater sampling. Assessed pesticide environmental fate mechanisms and degradates resultant from turf management practices.

Selected Project Management Experience (cont.):

1988-1989	Evaluated hazardous material haulers exposure to cargo during pick-up, transit, and off-loading. Established recommendations for personal protective equipment and work practices to reduce and eliminate significant exposures to cargo. Chemicals evaluated included the isocyanates, MDI and TDI and methylene chloride.
1986	Conducted a detailed health hazard evaluation of an EPA Superfund (CERCLA) site in New Jersey. Monitored hazardous waste site workers' exposure to a multitude of chemical contaminants.
1985-1987	Development and implementation of Occupational Medical Monitoring, Hearing Conservation, Lead, Asbestos and Hazard Communication programs for approximately 4,000 military and civilian personnel involved in manufacturing, office and residential environments. Measured exposures to benzene, aliphatic hydrocarbons, and other chemical and physical agents in industrial and shipboard environments.
1985	Conducted Asbestos and Lead Training Programs for shipyard workers involved in abatement procedures. Instructed workers in the areas of potential health hazards, health and safety measures and methods for reducing their exposure. Prepared labels for in-house product use.
1980-1982	Led a team of seven industrial hygienists in the NIOSH National Occupational Hazard Survey. My team visited approximately 1,500 facilities across the United States. We reviewed management practices related to employee safety and health, conducted wall-to-wall audits of the facility, reviewed product labels and MSDS, inventoried products and their constituents from readily available information and developed a product database.
1979	Conducted a wall-to-wall survey of a pharmaceutical facility evaluating worker exposures and recommended methods for regulatory compliance.

Professional Development Courses:

Risk Assessment Symposium, AIHA 6-7 November 2008, Tampa, FL

Introduction to Monte Carlo Uncertainty Analysis, PDC 8, 26 September 1999, PCIH '99

Risk Assessment, PDC 6, 26 September 1999, PCIH '99

Mathematical Models for Occupational Exposure Assessment, PDC 402, 6 June 1999, AIHCE

Professional Development Courses (cont.):

International Hazard Communication, AIHA/SCHC (12 hrs)

Environmental Toxicology, Hood College (24 hrs)

Man-Made Mineral Fibers: Status of Health Risk Assessment, Johns Hopkins University (12.5 hrs)

Health Hazard Recognition & Evaluation, OSHA Institute (80 hrs)

Health Hazard Recognition & Evaluation, NIOSH Training Institute (80 hrs)

Chemical Process Industries, University of Cincinnati (40 hrs)

Industrial Ventilation Conference, North Carolina State University (40 hrs)

Mechanisms of Toxicology, Johns Hopkins University (25 hrs)

Asbestos Symposium, Johns Hopkins University (8 hrs)

Loss Control Management, U. S. Coast Guard (40 hrs)

Pulmonary Medicine Topics, U.S. Navy Conference (8 hrs)

Navy Occupational & Environmental Health Workshop, U.S. Navy Conference (40 hrs)

Comprehensive Review of Industrial Hygiene, University of Utah (40 hrs)

Air Surveillance for Hazardous Materials, U.S. EPA (40 hrs)

Appropriate IH Data Collection for Future Occupational Epidemiology Studies (4 hrs)

Certified Indoor Air Quality Consultant Study/Review Course (20 hrs)

Selected Speaking Engagements:

2007 "A Validation Study of a Mathematical Model for Estimating Solvent Exposures in the Workplace." American Industrial Hygiene Conference and Exposition, June 2007.

"The Implications of Input Variables Selection When Modeling Occupational Exposures." American Industrial Hygiene Conference and Exposition, June 2007.

2003 "Estimating Past Exposures- The Scientific Basis for Reconstructing Asbestos Dose for Groups and Individuals." American Industrial Hygiene Conference, May 2003

Selected Speaking Engagements (cont.):

2002	"Where do we start? The proper response to an indoor air quality complaint. Investigation and testing techniques; determining causes; remediation," 18th Annual Maryland Workers' Compensation Educational Association Inc. Conference, 24 September 2002.
2001	"Generating Exposure Data on Historical Activities or Products", American Industrial Hygiene Conference, 4 June 2001.
	"Evaluation of Chemical Exposures in Mammography X-Ray Development," American Industrial Hygiene Conference, 4 June 2001.
	"Comparison of Direct and Indirect Sample Preparation Methods for Asbestos Analysis", American Industrial Hygiene Conference, 6 June 2001.
1999	"The Actual Contribution of Airborne Asbestos Fibers to the Work Environment From Asbestos Gaskets", American Industrial Hygiene Conference and Exposition, 7 June 1999.
1998	Federal Safety and Health Council of Central Maryland Health & Safety Programs: Auditing, Self-Assessments and Issues Tracking
1995	"Environmental Health & Safety Auditing — Performance Measures," Program Chairperson, Johns Hopkins University, Baltimore, Maryland, October 1995
	"Health & Safety Audits Course", Program Chairperson, Government Institute, Orlando, Florida, February 1995
	"Issues Critical to Growth", Maryland Chamber of Commerce, Baltimore Leadership Training, Baltimore, MD, 15 May 1995
1994	"Health and Safety Compliance Auditing Course", 3 days UNOCAL Corporation, Los Angeles, CA, August & September, 1994
	"Indoor Air Quality; Putting the Issues into Perspective", American Industrial Hygiene Association, Chesapeake Section, Professional Development Conference. U.S. Naval Academy, Annapolis, MD, October 1994
1994	"Computer Applications for Managing Health, Safety and Environmental Programs" Safety Council of Maryland, June 1994
	"Emergency Response Planning" Round table American Industrial Hygiene Conference, May 1994.

Selected Speaking Engagements (cont.):

1994 The OSHA Update Conference, Government Institutes, Inc., Washington, DC, 29-30 October 1992
— Health & Safety Audits

1992 The Environmental Management Development Summer Institute, Government Institutes, Washington, DC, 12 June 1992
— Hazard Communication Requirements
— Preparing for Inspections and Working with the Regulators

Chairperson for "Product Risk Assessment" Roundtable, AIHA National Meeting

Program Chairperson for "Health and Safety Auditing," Government Institute Programs

1989 Maryland Institute for Continuing Professional Education of Lawyers
Advanced Real Estate Institute
Environmental Issues in Land Development

1988 DMW/Cook, Howard, Downes and Tracy; Land Use Seminar
Property Investigations for Hazardous Substances for Real Estate Transactions

1987 USF&G Loss Control Seminar
Environmental Hazard Assessment

1986 U.S. Coast Guard Marine Safety Training School
Environmental and Occupational Hazard Assessment

Professional Conference Poster Presentations:

1. Plisko, M.J. and Spencer, J.W. 1999. *Measurement for Continuous Improvement of Health, Safety, and Environmental Programs.* American Industrial Hygiene Conference and Exposition, Toronto, Canada. June.
2. Spencer, J.W. 2000. *An Example of a Quantitative/Environmental Exposure Database-An Information Resource.* American Industrial Hygiene Conference and Exposition, Orlando, Florida. May.
3. Burrelli, L., Nealley, M., Plisko, M., Spencer, J. 2004. *Exposure Assessment: An Evaluation of Benzene from the Application and Use of Spiked Penetrating Solvents.* American Industrial Hygiene Conference and Exposition, Atlanta, Georgia. May.
4. Plisko, M. and Spencer, J. 2004. *Using a Physical-Chemical Mathematical Exposure Model for estimating Occupational Exposure.* American Industrial Hygiene Conference and Exposition, Atlanta, Georgia. May.

Professional Publications:

1. Torrence, P.R., and Spencer, J.W. 1978. "5- 0- Alkylated Derivatives of 5-Hydrox-2^1-deoxyuridine as Potential Antiviral Agents." *Journal of Medicinal Chemistry*. 21:228.
2. Gots, R.E., Gots, B.A., and Spencer, J. 1992. "Proving Causes of Illness in Environmental Toxicology: 'Sick Buildings' as an Example." *Fresenius Envir Bull*. 1:135.
3. Spencer, J.W. 1992. *Health and Safety Audits*. Government Institutes, Inc.
4. Rose, V.E. and Spencer, J.W. 1995. *Hazard Communication: An AIHA Protocol Guide*. AIHA Publication.
5. Spencer, J.W., Plisko, M., Balzer, R. 1999. "Asbestos Fiber Release from the Brake Pads of Overhead Industrial Cranes" *Occupational & Environmental Hygiene*. 14:397-402.
6. Nicas, M., Plisko, M.J., Spencer, J.W. 2006. "Estimating Benzene Exposure at a Solvent Parts Washer." *Journal of Occupational and Environmental Hygiene*. 3:284-291.
7. Spencer, J.W. and Plisko, M.J. 2007. "A Comparison Study Using a Mathematical Model and Actual Exposure Monitoring for Estimating Solvent Exposures During the Disassembly of Metal Parts." *Journal of Occupational and Environmental Hygiene*. 4:253-259.
8. Boelter, F.W., Spencer, J.W., Simmons, C.E. 2007. "Heavy Equipment Maintenance Exposure Assessment: Using a Time-Activity Model to Estimate Surrogate Values for Replacement of Missing Data." *Journal of Occupational and Environmental Hygiene*. 4:525-537.
9. Plisko, M.J. and Spencer, J.W. 2008. "Evaluation of a Mathematical Model for Estimating Solvent Exposure in the Workplace." *Journal of Chemical Health and Safety*. (15) 3:14-21.

APPENDIX II:

Benzene Dermal Flux Data for Various Liquid Mixtures Containing Variable Benzene Levels

Reference	Liquid Mixture	Benzene Conc.	Flux (mg/cm^2-hr)	*In vivo / in vitro*	Species & # subjects	Exposure Description	Comments
Hanke et al 1961	Neat benzene	100 %	0.4	*in vivo*	Human forearm, n=10	Occluded. Exposure under watch glass	Benzene vapor
Fiserova-Bergerova 1989	Neat benzene	100 %	0.19		Rat		Flux value taken from Tsuruta, 1982
Blank et al 1985	Gasoline	2% and reported flux normalized for 5%	0.062	*in vitro*	Human Abdomen	Autopsy skin – partial thickness. Exposure occluded. Glass diffusion chambers tightly capped. Flux values normalized for concentration	Stratum corneum was dried over Dririte when it was used for determining patrician coefficients.
Blank et al 1985	Hexadecane	5% (v/v)	0.047	*in vitro*	Human Abdomen	Autopsy skin – partial thickness. Exposure occluded. Glass diffusion chambers tightly capped. Flux values normalized for concentration	Different flux values reported for pure benzene, benzene vapor, and various solvents
Blank et al 1985	Hexane	5% (v/v)	0.105	*in vitro*	Human Abdomen	Autopsy skin – partial thickness. Exposure occluded. Glass diffusion chambers tightly capped. Flux values normalized for concentration	
Susten et al 1985	Naphtha Distillate (rubber solvent)	0.5% (v/v) 0.14%	0.011 (calculated, not reported in original paper)	*in vivo*	mice Hairless mid-dorsal back n=12	Semi-occluded - stainless steel skin-depot attached to the skin. Mice were anesthetized with carbon dioxide.	rubber solvent: largely comprised of C4-C7 aliphatic hydrocarbons and a small percentage of aromatics including benzene (0.09%), toluene (5.7%), and xylenes (0.4%).
Susten et al 1985	Neat Benzene	100%		*in vivo*	mice Hairless mid-dorsal back n=7	Semi-occluded - stainless steel skin-depot attached to the skin. Mice were anesthetized with carbon dioxide.	Percent penetration reported as 0.89 and 0.88%
Blank et al	Isooctane	5% (v/v)	0.187	*in*	Human	Autopsy skin –	

Reference	**Liquid Mixture**	**Benzene Conc.**	**Flux (mg/cm^2-hr)**	***In vivo / in vitro***	**Species & # subjects**	**Exposure Description**	**Comments**
1985				*vitro*	Abdomen	partial thickness. Exposure occluded. Glass diffusion chambers tightly capped. Flux values normalized for concentration	
Adami et al 2006	Gasoline	0.74% 0.39% 1.06%	0.00271 0.00180 0.00147	*in vitro*	Human		
Loden, 1986	Neat benzene	100 %	0.099	*in vitro*	Human	Skin bathed in benzene at 5 mls/hour	
Franz 1982	Neat benzene	100 %	0.25	*in vitro*	Human	Split thickness abdominal skin from autopsy	
McDougal et al 1990	Neat benzene	100 %		*in vivo*	Rat - n=6	whole body in exposure chambers – no inhalation exposure	Permeability constant reported 0.152 cm/hr
Nakai at al 1997		15-50 mcg/L_{H2O}		*in vitro*	Human Abdomen & breast	Tissue donated from elective surgeries. Samples in circulating pool	Permeability constant reported 0.14 cm/hr
Maibach & Anjo 1981		100 % 0.35 %		*in vivo*	Monkey	Multiple exposure scenarios including single and repeated does, and single exposures to intact and damaged skin.	
Arfsten et al 2006	Mix of oils & isoparafinic hydrocarbons			*in vivo*	Humans Mice Rats Pigs		
Boman and Maibach 2000	n-butanol Toluene			*in vitro*	Human n=4	Split thickness skin from autopsy. Flow through penetration evaporation cells	
Modjtahedi & Maibach 2008	Neat benzene	100%		*in vivo*	Human n=4	Single exposure to intact skin. No inhalation exposure. Skin open to air: palmar exposure (fume hood) and Forearm in open air.	

APPENDIX III:

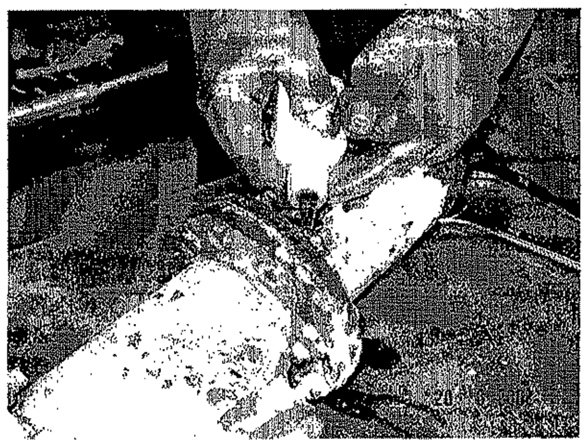
"Exposure Assessment: An Evaluation of Benzene from the Application and Use of a Prepared Liquid Wrench Solvent in Static Environmental Conditions."

Report of Findings

Exposure Assessment: An Evaluation of Benzene from the Application and Use of a Prepared Liquid Wrench Solvent in Static Environmental Conditions

EPI Project No. 22472

27 September 2002



Prepared by:

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Baltimore, Maryland 21228
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Report of Findings

Exposure Assessment: An Evaluation of Benzene from the Application and Use of a Prepared Liquid Wrench Solvent in Static Environmental Conditions

EPI Project No. 22472

Table of Contents

Purpose

The purpose of this study was to evaluate the exposure of a worker and a helper to benzene when using preparations of Liquid Wrench containing various weight concentrations of benzene. In order to evaluate these exposures, three batches of Liquid Wrench were spiked with known weight percentages of benzene. Specifically, preparations of the Liquid Wrench/benzene (LW/benzene) solution were made in 1%, 7% and 30% concentrations of benzene by weight.

Figure 1. Containers of Liquid Wrench used for the study. Duplicate samples were prepared for each weight percentage. The 1%, 7% and 30% benzene preparations are shown.

Study Methods

Prior to the study, two background air samples were collected within the warehouse at approximately 5 feet from the designated work area and two air samples were collected from outside the warehouse. They were analyzed for potential background levels of benzene.

In order to evaluate the exposures during the use of the LW/benzene preparations, three valve assemblies each comprised of at least three flanges with rusted bolts and nuts were used during the study. Each of the three valve assemblies was evaluated independently using one of the three LW/benzene preparations. Each weight percentage of benzene in Liquid Wrench was used on a respective flange assembly for a period of two hours during the exposure study beginning with 1% benzene followed by 7% benzene and finally 30% benzene. However, during the evaluation of the 7% and 30% LW/benzene mixtures, the flange assembly used for the 1% LW/benzene was also used. The bolts and nuts on this first flange assembly were most difficult to loosen and were also used with the 7% and 30% LW/benzene mixtures.

Long and short-term personal breathing zone samples were collected for the worker and helper. The samples were submitted to an American Industrial Hygiene Association (AIHA) accredited laboratory for analysis. The results were compared to the 8-hour time weighted average (TWA) permissible exposure limit (PEL) and the 15-minute short-term exposure limit (STEL) established by the Occupation Safety and Health Administration (OSHA).

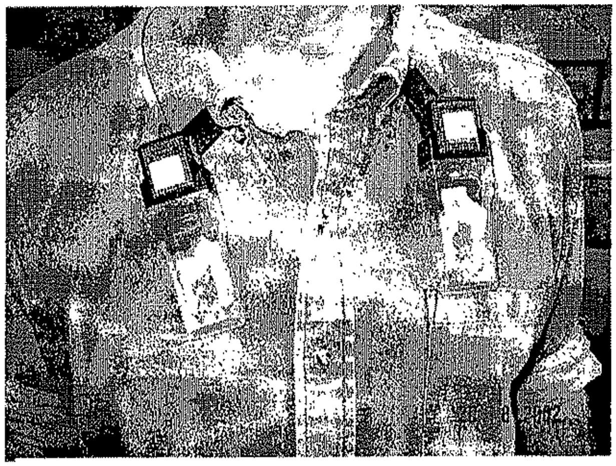

Figure 2. Worker shown wearing two dual port sampling devices with charcoal tube media in place during the study.

Direct read air sampling for benzene was conducted using colorimetric detector tubes during the application of the LW/benzene product to determine airborne benzene levels. The work was conducted on a plastic covered workbench, placing the worker in close proximity to the LW/benzene product following application. Air velocity measurements were taken before and during the solvent applications.

The Liquid Wrench used for the study was obtained from Home Depot in Catonsville, MD. It came packaged in separate white plastic containers with capped delivery spouts. The labeled product quantity for each container was nominally 118 milliliters (ml). The product "Part No." was identified as "L104." A Material Safety Data Sheet (MSDS) for the product used is provided as Appendix C to this report. Figure 1 shows the containers of LW/benzene used for this study.

The full study design is presented in the prepared protocol entitled *"Protocol for Assessing Benzene Exposure During Actual and Simulated Mechanical Tasks Utilizing Liquid Wrench"* shown in Appendix B of this report.

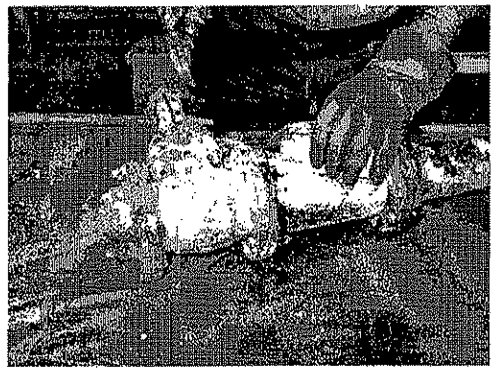

Figure 3. Representative photos showing the application of Liquid Wrench containing benzene. The hammer shown at right was used to lightly tap on the rusted bolts and nuts.

All air sample collection and analyses were conducted in accordance with *NIOSH Manual of Analytical Methods, No. 1501-Aromatic Hydrocarbons* using MSA Escort ELF battery operated sampling pumps. All samples were submitted to an independent qualified laboratory, American Medical Laboratories in Chantilly, VA for analysis.

Figure 4. Worker shown applying Liquid Wrench/benzene solvent and tapping with a hammer. Dual sampling port devices are shown on the worker at his breathing zone and one area dual port sampler is shown in the foreground.

Work tasks included the application of the Liquid Wrench/benzene mixture to loosen the rusted nuts and bolts. The quantity of solution prepared for each weight concentration was determined prior to performing the study. The amount of solution used in each trial was calculated following the study by subtracting the amount of material remaining in the containers from the amount of material starting in each container. These volumes are shown in Table 1. Figures 3 and 4 show the application and use of the LW/benzene solvent during the work tasks.

Figure 5. Study work area showing the worker in the background. Polyethylene wall at left of picture is an existing structure. Warehouse doors at right were closed.

Table 1 shows the quantity of Liquid Wrench removed and replaced with benzene to achieve the target LW/benzene percentage for each preparation. In addition, the Table shows the actual percentage of benzene for each mixture as determined by laboratory analysis and the quantity of LW/benzene mixtures used during the assessment study.

Table 1. Benzene Content of Liquid Wrench Used in the Study

Original Quantity of Liquid Wrench	Quantity of Liquid Wrench Removed	Quantity of Benzene Added	Quantity of Liquid Wrench/Benzene Used in Study	Target Weight Percentage of Benzene in Liquid Wrench	Actual Weight Percentage of Benzene in Liquid Wrench as Measured by Laboratory
Control Sample 142 ml	0	0	0	0%	< LOQ*
284 ml	3.0 ml	2.8 ml	153.2 ml	1%	0.98%
285 ml	20.0 ml	18.5 ml	32.0 ml	7%	6.8%
284 ml	85.2 ml	78.9 ml	42.5 ml	30%	28.0%

*Limit of Quantitation = 0.029%

Note: One hundred twenty five milliliters (125 ml) of Liquid Wrench/Benzene was placed in each of the two containers for each Liquid Wrench/Benzene weight concentration made. Therefore, a total of 250 ml was made for 1%, 7% and 30% benzene solutions by weight. The remaining LW/Benzene solution not placed into the Liquid Wrench containers were submitted to the laboratory to determine the actual weight percentage of benzene in the Liquid Wrench solution. The first sample shown in the Table is the Control Sample. No benzene was added to this sample.

Bulk samples of the original Liquid Wrench product and each LW/benzene mixture preparation were also analyzed for quantitative determination of benzene content by GC/FID analysis.

The air velocity was measured using a TSI Incorporated *Velocicheck*® Model 8330 Air Velocity Meter. The work area consisted of a tabletop bench covered in 6-mil (0.006") polyethylene plastic sheeting. The table was placed in a warehouse alongside a polyethylene wall 18 feet long by 10 feet high. The polyethylene wall was an existing structure within the warehouse. The table was approximately 12 feet from the rear wall of the warehouse and approximately ten feet from the outer warehouse doors. The doors remained closed during the study. Figure 5 is a photograph of the work area used during the study.

Results

The actual percentage of benzene in each prepared LW/benzene solution was completed by laboratory analysis and is reported in Table 1. The targeted 1%, 7% and 30% benzene mixture preparations were determined by laboratory analyses to be 0.98%, 6.8% and 28.0%, respectively.

The detailed results of the exposure assessment study are presented in the Data Tables shown in Appendix A of the report. Tables 3 through 5 present the worker, helper and area air sample results for the actual 0.98% of benzene in Liquid Wrench; Tables 6

through 8 show the worker, helper and area air sample results for 6.8% of benzene in Liquid Wrench; and, Tables 9 through 11 represent the worker, helper and area air sample results for 28.0% of benzene in Liquid Wrench.

The results show that the worker and helper were not exposed to benzene in air at levels greater than the current OSHA 8 hour TWA permissible exposure limit of 1 part per million (ppm). Twenty-seven air samples were collected for 15-minute short-term exposure limit (STEL) determination from the worker and helper during the entire study. One sample of the 27 collected and analyzed for the worker and helper marginally exceeded the OSHA 15-minute STEL of 5 ppm. The one sample that exceeded this limit was reported at 5.03 ppm and was collected from the worker during the work task associated with the use of the 6.8% LW/benzene.

Area air samples collected and analyzed for benzene were reflective of by-stander exposure. The results of the area samples presented in the Tables 5, 8 and 11 of Appendix A show that benzene in air for the area samples at a distance of five feet ranged from 0.10 ppm to 0.319 ppm for a two-hour period. Eight-hour TWA calculations based on these values are below the OSHA PEL for benzene.

The measured air velocity in the worker's breathing zone was measured at zero to six feet per minute (fpm).

Benzene was not detected in the two indoor or two outdoor background air samples collected the day prior to the LW/benzene solvent study. Table 2 shows the analytical results for the background samples.

Table 2. Background Air Sample Results for Benzene Prior to Study

Sample Number	Sample Location	Analytical Limit of Quantitation (ppm)	Concentration of Benzene in Air (ppm)
081902-SC01	Outdoors	0.024	<0.024
081902-SC02	Outdoors	0.024	<0.024
081902-SC03	Indoors – 5' east of work study area	0.024	<0.024
081902-SC04	Indoors – 5' west of work study area	0.024	<0.024

Discussion

The assessment was undertaken on a worktable covered by a 6-mil polyethylene sheet. This permitted the pooling of solvent on the tabletop and was probably not reflective of a real world use of the Liquid Wrench. However, use of the polyethylene sheet presented the worker and helper with what could be considered a worst-case scenario since the solvent was allowed to pool on the surface instead of flowing away from the work piece.

The LW/benzene product was applied in a manner typical for its intended use. The work task was conducted in a static environment where air movement was measured at zero to six fpm. Therefore, the air velocity measurements during the assessment were found to have been negligible. Due to this static environment, a worst-case scenario for vapor exposure was established.

Air monitoring for benzene during the use of known concentrations of benzene in Liquid Wrench found that the current OSHA 8-hour TWA permissible exposure limit for benzene was not exceeded for concentrations of benzene in Liquid Wrench up to 28.0% by weight. One of the 18 STEL samples for the worker marginally exceeded (i.e., 5.03 ppm) the OSHA 15-minute STEL of 5 ppm during the use of the 6.8% LW/benzene mixture.

Each of the three LW/benzene mixtures, i.e., 0.98%, 6.8% and 28.0% benzene by weight, were evaluated over a two-hour period. The quantity of each mixture used varied depending on the severity of rust and corrosion on the nuts and bolts for each flange assembly. The first flange assembly used during the 0.98% by weight mixture had the most difficult bolts to remove. In fact, the bolts that were removed were done so only by breaking the bolt heads off of the flange assembly.

For the first flange assembly, approximately 153 ml of solvent containing the 0.98% benzene by weight was used. For each of the subsequent 2-hour periods for the 6.8% and 28.0% benzene by weight solvents, approximately 32 ml and 42 ml of solvent were used, respectively.

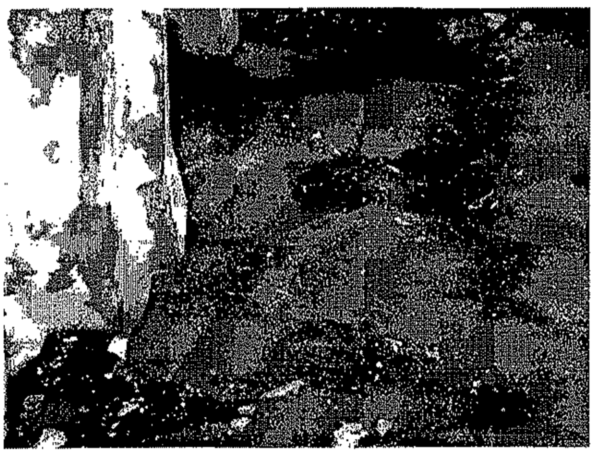

Figure 6. Note the pooling of LW/benzene solvent on the polyethylene sheet atop of the tabletop.

The study was performed in order to maximize the potential for worker exposure to airborne levels of benzene. This "worst-case" scenario was purposefully established for each of the three concentrations of LW/benzene. Study design factors establishing the worst-case scenario were: 1) lack of ventilation in the study area, establishing a static

environment for the worker, 2) plastic sheeting on the work bench which permitted pooling of the liquid solvent, 3) repeated application of LW/benzene over a two-hour period for each prepared mixture, and 4) the worker maintaining close proximity to the work area during each two-hour study period, i.e., the worker was never more than 10 feet from the work area.

Despite the design parameters optimizing the potential for vapor exposure to the worker and helper, the results show none of the measured values exceeding the 8-hour TWA for benzene and one sample out of 27 marginally exceeding the 15-minute STEL for benzene. This one sample that exceeded the STEL was collected during the 6.8% benzene, not the highest concentration preparation of 28.0% benzene. The highest STEL measurement at the 28.0% benzene mixture was 3.53 ppm.

Conclusions

Based on the results of the study, users of Liquid Wrench containing up to 28.0% benzene by weight would not be exposed above the current OSHA 8-hour TWA permissible exposure limit during the normal use of the product in a typical ventilated workplace environment. Usage of the Liquid Wrench in a well-ventilated setting as recommended by product labeling would serve to further significantly reduce the exposure to the vapors including any benzene that may be present.

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27 September 2002
Date